Science Theater

ATOMIC STRUCTURE

Lesson 1 | Matter, Molecules and Atoms

1/10

Science Field:
Materials Science

Topic:
Matter, Molecules and Atoms

KEY CONCEPT

Matter is anything that has mass and occupies space.

Everything around us on the Earth's surface is matter.

HOW MATTER IS BUILT

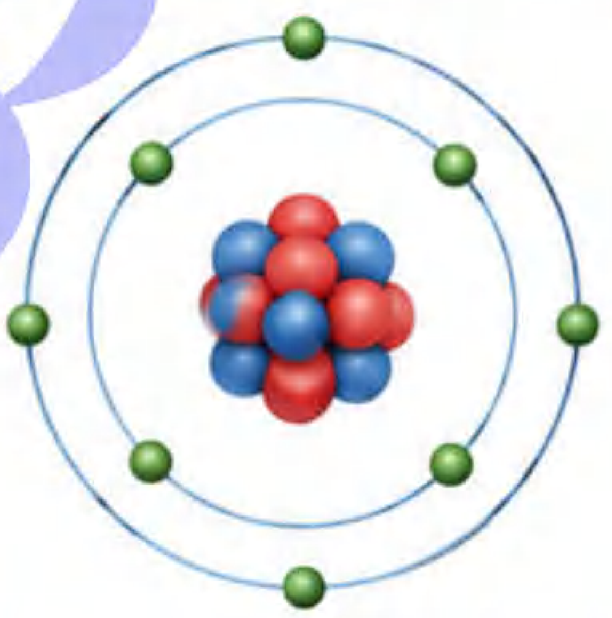
1 Objects / materials around us

Example:
A piece of limestone

2 Molecules

Example:
calcium carbonate molecules

3 Atoms



Example:
atoms

DEFINITION

Atom: the basic building unit of matter.

Matter is made of extremely tiny particles called atoms.

IMPORTANT NOTE

- Molecules are made of atoms.
- Atoms combine to build all materials.

WHAT YOU WILL LEARN IN THIS LESSON

- Structure of the atom
- Chemical symbols
- Atomic number and mass number
- Energy levels and electron distribution
- Isotopes

ATOMIC STRUCTURE

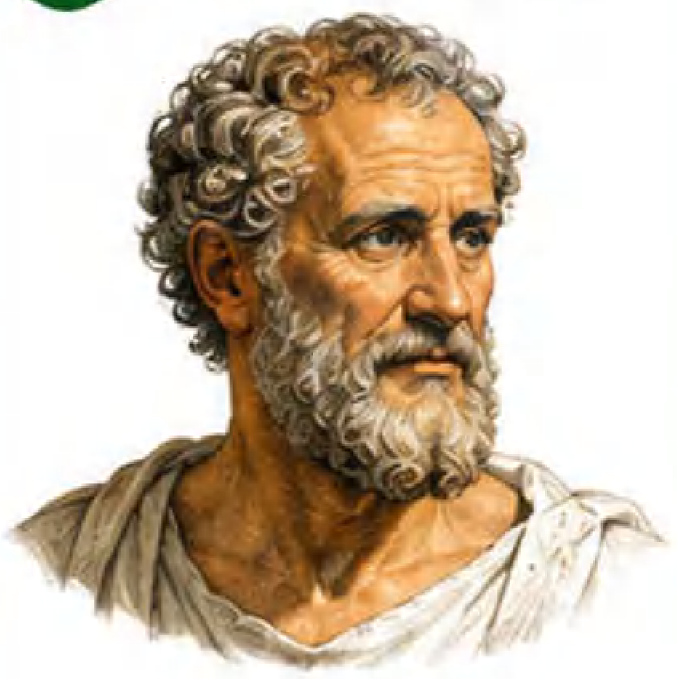
Lesson 1 | How the Atomic Model Developed

Science Field: Materials Science

Topic: Development of the Atomic Model

DISCOVERING THE ATOM THROUGH TIME

1 Ancient Times

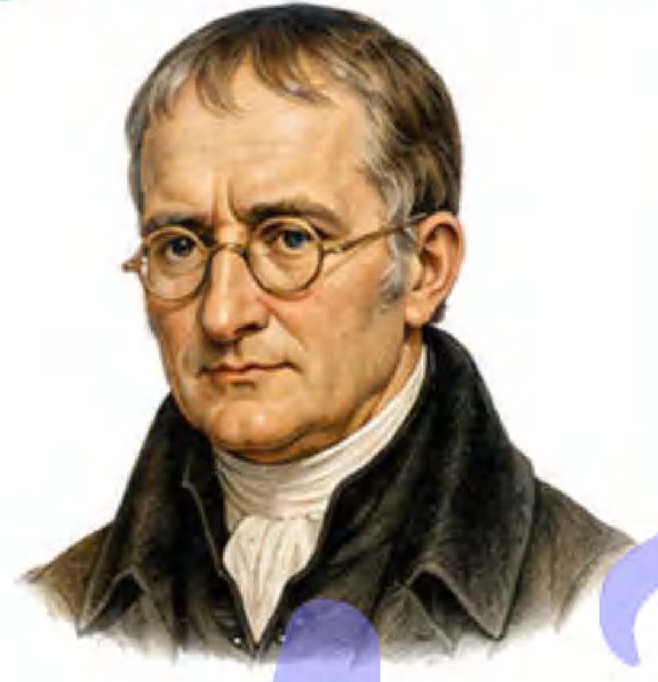


Democritus

Democritus suggested that matter is made of extremely tiny particles called atoms.

This was an early idea about the structure of matter.

2 Early Nineteenth Century

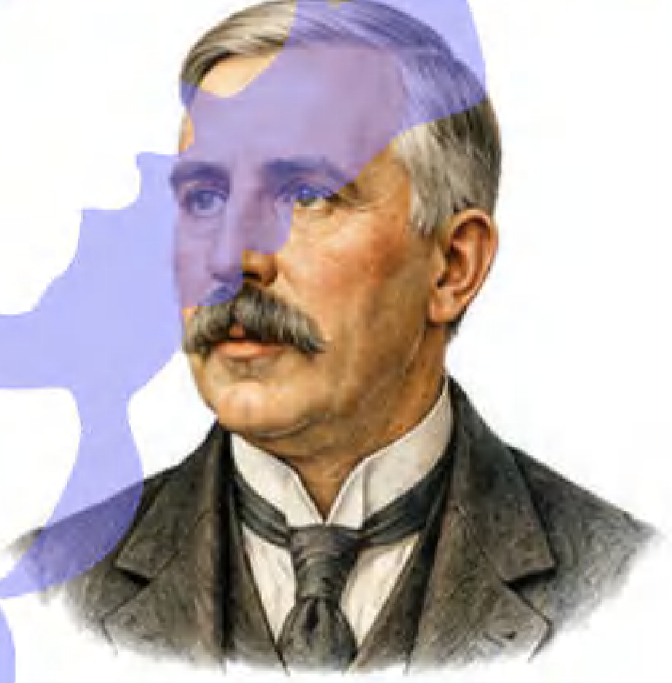


John Dalton

Dalton proposed an atomic theory that explained that matter is made of atoms.

His work helped scientists understand atoms in a clearer scientific way.

3 Early Twentieth Century



Ernest Rutherford

Rutherford proposed the nuclear model of the atom.

His work showed that the atom has a tiny central nucleus.

REMEMBER

- The idea of the atom developed gradually over time.
- Scientists moved from a simple idea to a clearer model of atomic structure.

IMPORTANT FIGURE

Ernest Rutherford received the Nobel Prize in Chemistry in 1908.

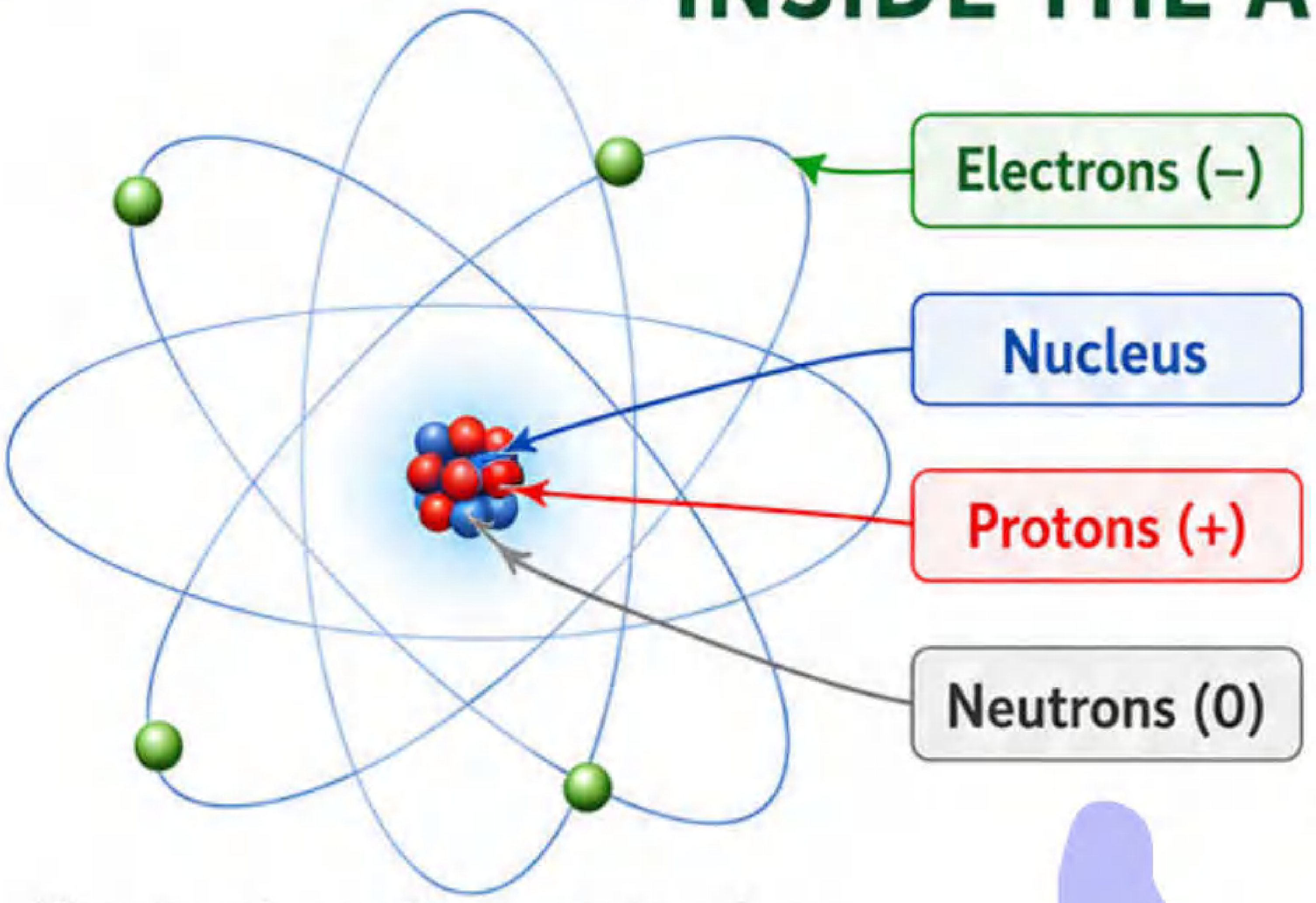
LEARNING PROGRESS

Idea of atoms → Atomic theory → Nuclear model

Science Field: Materials Science

Topic: Structure of the Atom

INSIDE THE ATOM



The atom has a tiny central nucleus, and electrons move around it.

KEY CONCEPT

The atom has a complex structure.

- The nucleus is at the centre of the atom.
- Electrons occupy the space around the nucleus.

1 Proton

Symbol: p
Charge: +1
Relative mass: 1 u

2 Neutron

Symbol: n
Charge: 0
Relative mass: 1 u

3 Electron

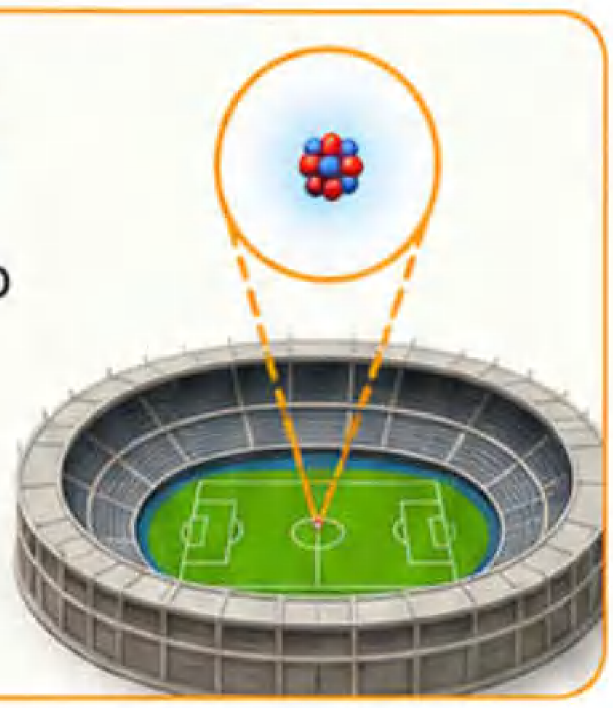
Symbol: e^-
Charge: –1
Relative mass: 1/1836 u

PROPERTIES OF THE SUBATOMIC PARTICLES

Particle	Symbol	Relative charge	Relative mass
Proton	p	+1	1 u
Neutron	n	0	1 u
Electron	e^-	–1	1/1836 u

DID YOU KNOW?

If the atom were enlarged to the size of a stadium, the nucleus would be very tiny in comparison.



REMEMBER

- Protons and neutrons are found in the nucleus.
- Electrons are found around the nucleus.

ATOMIC STRUCTURE

Lesson 1 | Chemical Symbols

Science Field: Materials Science

Topic: Chemical Symbols of Elements

KEY CONCEPT

Each element has a chemical symbol.

Scientists use symbols to make it easier to represent elements.

A When the symbol matches the element name

The symbol may be taken from the first letter of the element name.

C	N	Cl	Cr
Carbon	Nitrogen	Chlorine	Chromium

B When the symbol differs from the English name

Some symbols are derived from Latin names.

Na	K	Cu	Fe
Sodium (Natrium)	Potassium (Kalium)	Copper (Cuprum)	Iron (Ferrum)

RULES FOR WRITING SYMBOLS

① A one-letter symbol is written as a capital letter only. Example: **N** not **n**

② A two-letter symbol is written with the first letter capital and the second letter small. Example: **Na** not **NA**, **na**, or **nA**

★ Sodium is written as **Na**, not **S**, because its symbol comes from its Latin name.

EXAMPLES OF COMMON ELEMENT SYMBOLS

H	He	O	F	Mg	Ca
Hydrogen	Helium	Oxygen	Fluorine	Magnesium	Calcium
Cl	**Cu**	**Fe**	**Na**	**K**	**Ag**
Chlorine	Copper	Iron	Sodium	Potassium	Silver

APPLICATION: NPK FERTILISER

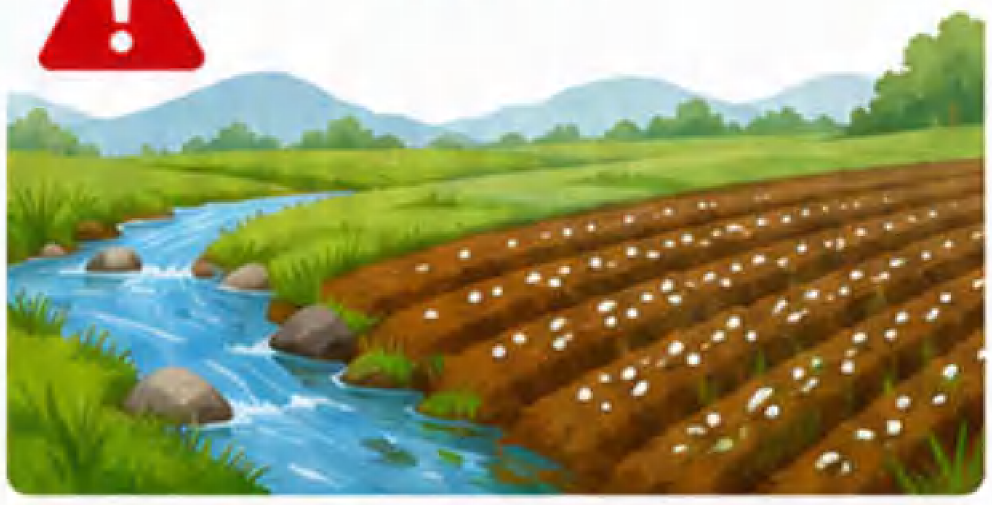
N = Nitrogen — helps in the formation of chlorophyll in leaves.

P = Phosphorus — helps root growth.

K = Potassium — necessary for plant growth.

NPK fertiliser contains compounds of nitrogen, phosphorus, and potassium.

CAUTION



Excessive use of fertilisers may pollute the soil and water.

Science Field: Materials Science

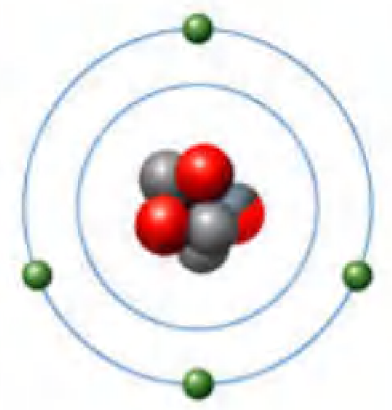
Topic: Atomic Number, Mass Number, and Particle Counts

ATOMIC NUMBER AND MASS NUMBER

KEY CONCEPT

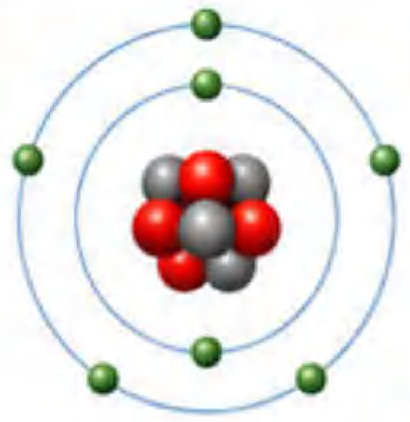
Relationship between subatomic particles in a neutral atom

Lithium atom



- Protons = 3
- Electrons = 3
- Neutrons = 4

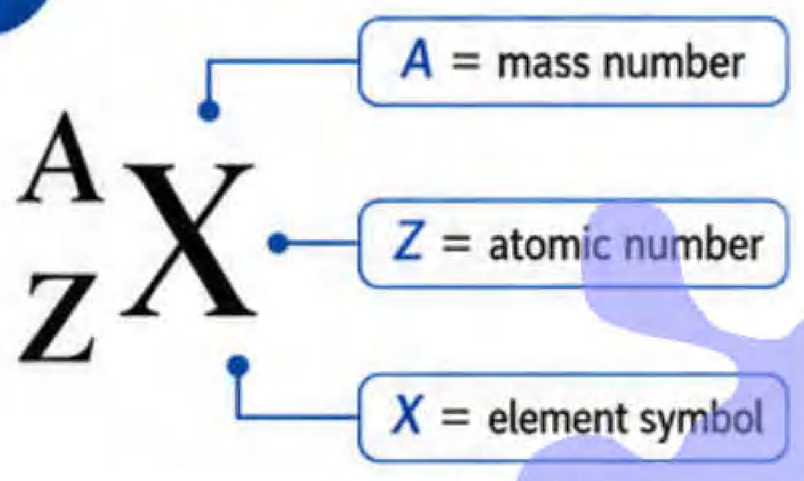
Carbon atom



- Protons = 6
- Electrons = 6
- Neutrons = 6

- In a neutral atom: number of protons = number of electrons.
- The atom is electrically neutral because the negative electrons balance the positive protons.
- In some atoms, the number of neutrons may be greater than the number of protons.

NUCLEAR NOTATION



$$^{A}_{Z}X$$

A = mass number

Z = atomic number

X = element symbol

- **Mass number (A):** total number of protons and neutrons in the nucleus.
- **Atomic number (Z):** number of protons in the nucleus.

WORKED EXAMPLE

$$^{35}_{17}\text{Cl}$$

- Atomic number = 17 → number of protons = 17
- In a neutral atom, number of electrons = 17
- Number of neutrons = 35 − 17 = 18

USEFUL RELATIONS IN A NEUTRAL ATOM

$$Z = p = e$$

$$A = p + n$$

$$n = A - Z$$

$$p = A - n$$

In a neutral atom, mass number can also be found from protons plus neutrons.

EXAMPLES

Nuclear Symbol	Element	Protons (p)	Electrons (e)	Neutrons (n)
$^{23}_{11}\text{Na}$	Sodium	11	11	12
$^{35}_{17}\text{Cl}$	Chlorine	17	17	18
$^{40}_{20}\text{Ca}$	Calcium	20	20	20

THINK & ANSWER

If a sulfur atom has 16 protons and 16 neutrons, what is its nuclear symbol?

$$^{32}_{16}\text{S}$$

ATOMIC STRUCTURE

Lesson 1 | Energy Levels

Science Field: Materials Science

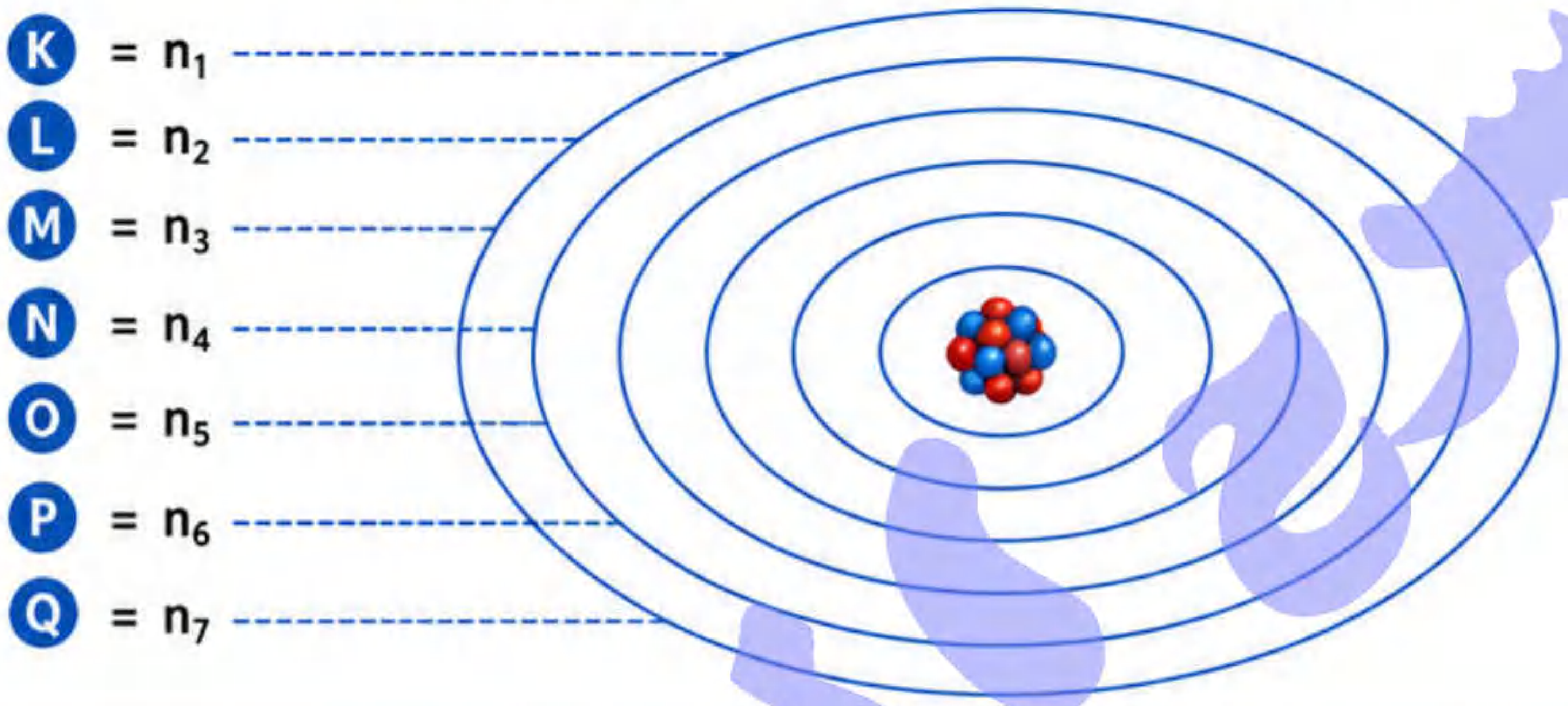
Topic: Energy Levels Around the Nucleus

KEY CONCEPT

Electrons move around the nucleus in fixed paths called energy levels.

Each path has a specific energy.

ENERGY LEVELS AROUND THE NUCLEUS



Energy increases with distance from the nucleus

- The closer the energy level is to the nucleus, the lower its energy.
- The farther the energy level is from the nucleus, the higher its energy.
- **K** is the first energy level and the closest to the nucleus.
- **Q** is the seventh energy level and the farthest from the nucleus.

MAIN ENERGY LEVELS

Level	Symbol	Principal number	Position
First	K	1	closest to the nucleus
Second	L	2	farther than K
Third	M	3	farther than L
Fourth	N	4	farther than M
Fifth	O	5	farther than N
Sixth	P	6	farther than O
Seventh	Q	7	farthest from the nucleus

REMEMBER

- ✓ The atom contains seven main energy levels.
- ✓ Energy level **K** has the lowest energy.
- ✓ Energy level **Q** has the highest energy.

ATOMIC STRUCTURE

Lesson 1 | Electron Capacity of Energy Levels

Science Field: Materials Science

Topic: Maximum Number of Electrons in Main Energy Levels

MAXIMUM ELECTRONS IN MAIN ENERGY LEVELS

KEY CONCEPT

The maximum number of electrons that can occupy a main energy level can be calculated from the relation $2n^2$.

n = number of the main energy level.

VISUAL FORMULA

$$2n^2$$

STEP

Substitute the number of the main energy level for **n**.

1 K level
$n = 1$
$2 \times (1)^2$
= **2** electrons

2 L level
$n = 2$
$2 \times (2)^2$
= **8** electrons

3 M level
$n = 3$
$2 \times (3)^2$
= **18** electrons

4 N level
$n = 4$
$2 \times (4)^2$
= **32** electrons

ELECTRON CAPACITY OF MAIN ENERGY LEVELS

Main level	Level number (n)	Maximum electrons
K	1	2
L	2	8
M	3	18
N	4	32

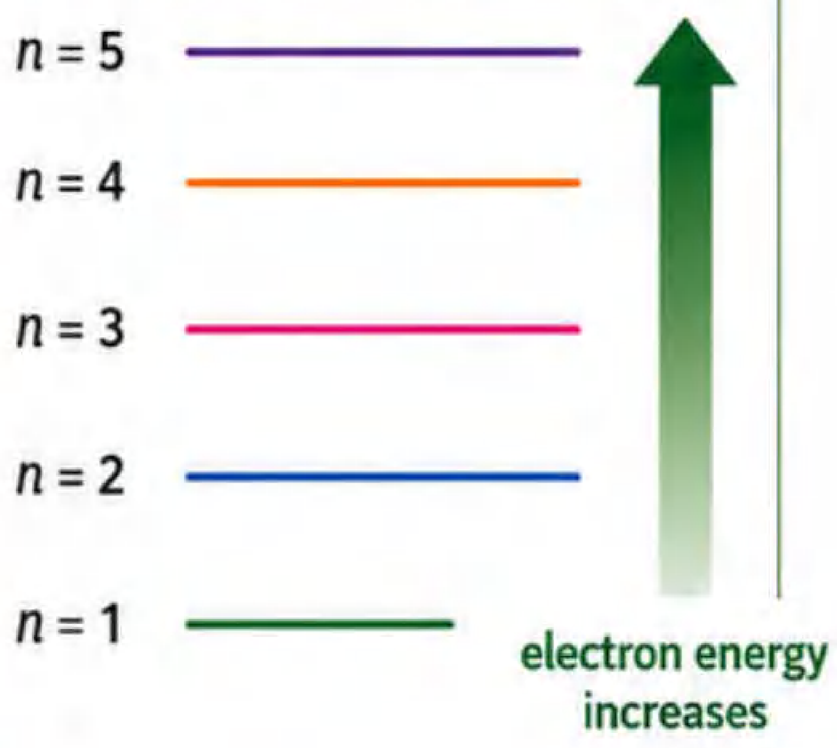
ELECTRON ENERGY AND DISTANCE

- The energy of the electron increases as the occupied level becomes farther from the nucleus.
- The energy difference between nearby levels becomes smaller as we move farther from the nucleus.

EXAMPLE

The energy difference between L ($n = 2$) and M ($n = 3$) is smaller than between K ($n = 1$) and L ($n = 2$).

ENERGY LEVELS (MAIN SHELLS)



REMEMBER

✓ Use $2n^2$ to find the maximum number of electrons in a main energy level.

✓ **K** holds **2** electrons; **L** holds **8**; **M** holds **18**; **N** holds **32**.

ATOMIC STRUCTURE

Lesson 1 | Electron Distribution

Science Field: Materials Science

Topic: Rules of Electron Distribution in Energy Levels

RULES OF ELECTRON DISTRIBUTION

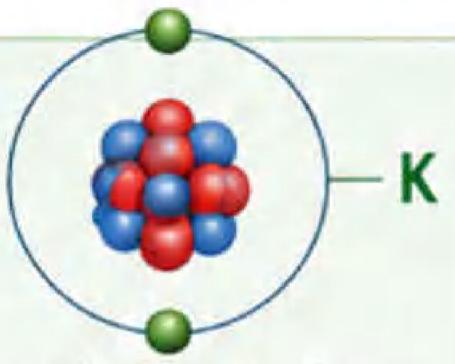
KEY CONCEPT

Electrons are distributed among the main energy levels around the nucleus.

The distribution follows fixed rules.

1 Rule 1

The first main energy level K is filled first.



K can hold a maximum of 2 electrons only.

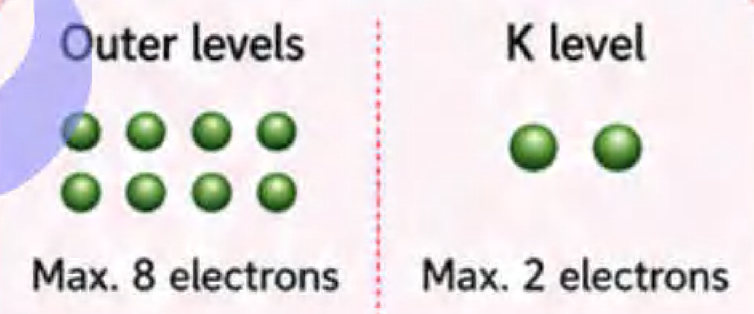
2 Rule 2

When one main energy level is completed, the remaining electrons move to the next energy level.

K → L → M → N

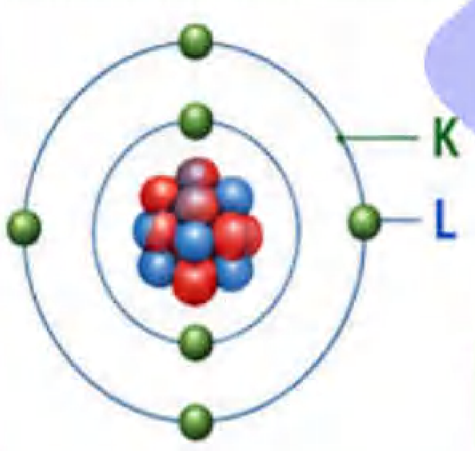
3 Rule 3

The outermost occupied main energy level should not contain more than 8 electrons, except the K level, which does not contain more than 2 electrons.



Application 1: Oxygen atom ($_{8}\text{O}$)

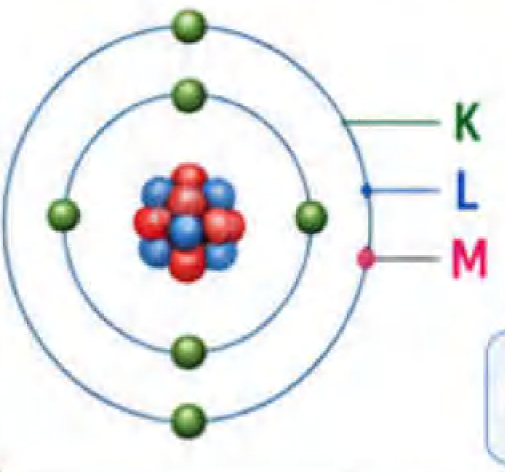
1. Atomic number = 8 → number of electrons = 8
2. K level receives 2 electrons
3. Remaining electrons = 6 → L level receives 6 electrons



Electron distribution: **2, 6**

Application 2: Magnesium atom ($_{12}\text{Mg}$)

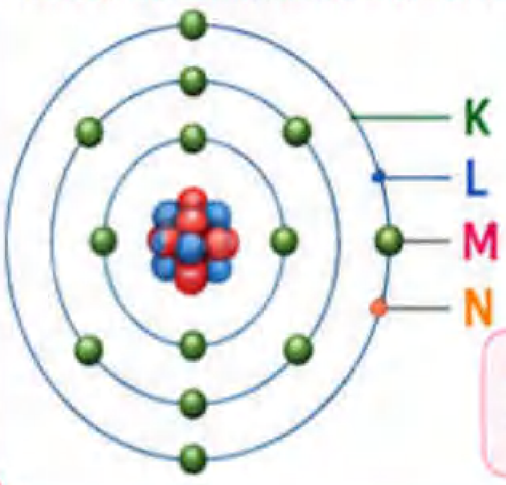
1. Atomic number = 12 → number of electrons = 12
2. K level receives 2 electrons
3. Remaining electrons = 10 → L level receives 8 electrons
4. Remaining electrons = 2 → M level receives 2 electrons



Electron distribution: **2, 8, 2**

Application 3: Calcium atom ($_{20}\text{Ca}$)

1. Atomic number = 20 → number of electrons = 20
2. K level receives 2 electrons
3. Remaining electrons = 18 → L level receives 8 electrons
4. Remaining electrons = 10 → M level receives 8 electrons
5. Remaining electrons = 2 → N level receives 2 electrons



Electron distribution: **2, 8, 8, 2**

REMEMBER

- O Oxygen: 2, 6
- Mg Magnesium: 2, 8, 2
- Ca Calcium: 2, 8, 8, 2

ATOMIC STRUCTURE

Lesson 1 | Reading Electron Distribution

Science Field:
Materials Science

Topic:
Using Electron Distribution to Identify Atomic Data

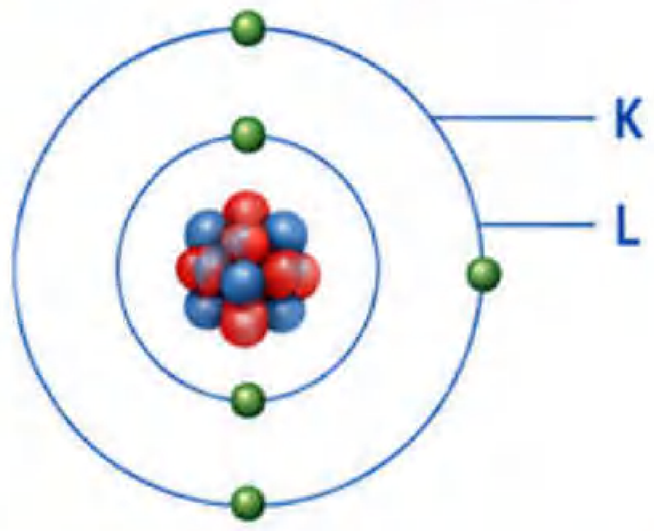
READING ELECTRON DISTRIBUTION

KEY CONCEPT

In a neutral atom, the atomic number equals the total number of electrons distributed in its energy levels.

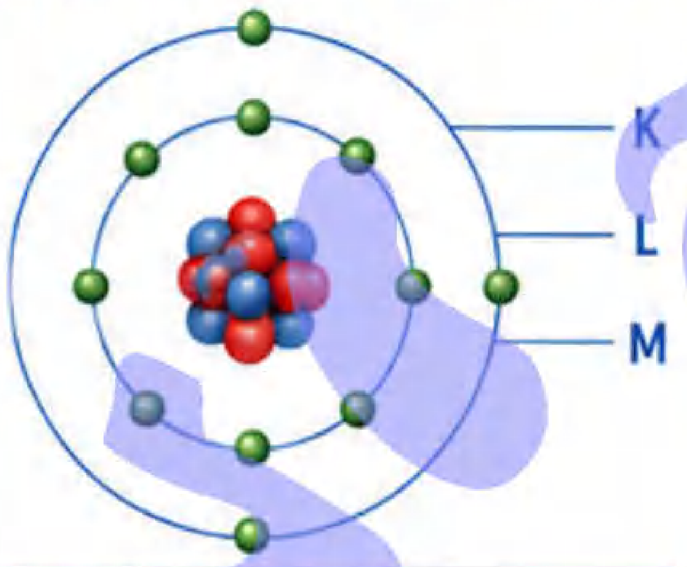
Atomic number (Z) = total number of electrons

A Nitrogen atom ($_7N$)



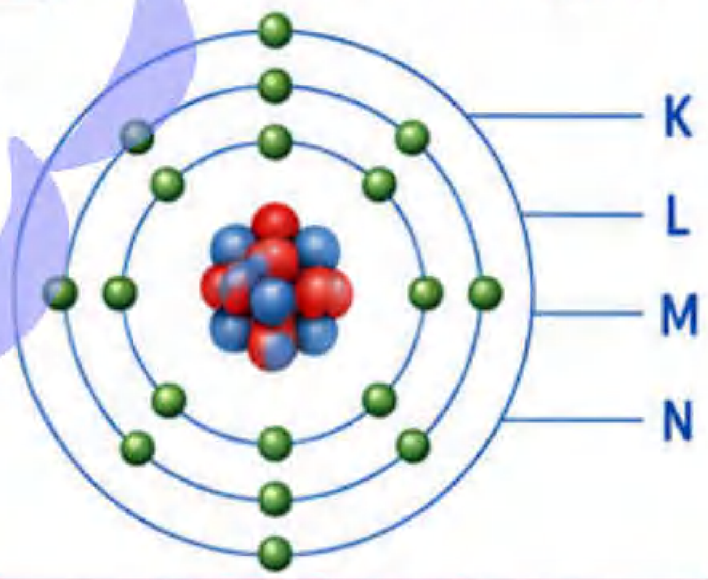
Final electron distribution:
2, 5

B Aluminium atom ($_{13}Al$)



Final electron distribution:
2, 8, 3

C Potassium atom ($_{19}K$)



Final electron distribution:
2, 8, 8, 1

EXAMPLES OF ELECTRON DISTRIBUTION

Element	K	L	M	Total electrons	Occupied levels
H	1	–	–	1	1
Li	2	1	–	3	2
F	2	7	–	9	2
Na	2	8	1	11	3
Cl	2	8	7	17	3

REMEMBER

To find the atomic number of a neutral atom, add the electrons in all occupied energy levels.

WORKED PROBLEM 1

An atom has 31 nucleons in its nucleus, three energy levels, and 5 electrons in the outermost level.

- Electron distribution = 2, 8, 5 ➜
- Total electrons = 15 ➜
- Atomic number = 15 ➜
- Number of neutrons = 31 – 15 = 16

WORKED PROBLEM 2

An atom has four energy levels and the same number of electrons in each level except the first and last.

- Distribution = 2, 8, 8, 2 ➜
- Atomic number = 20 ➜
- Mass number = 40 ➜
- Number of neutrons = 40 – 20 = 20

ATOMIC STRUCTURE

Lesson 1 | Isotopes and Review

Science Field:
Materials Science

Topic:
Isotopes and Lesson Review

ISOTOPES

KEY CONCEPT

Atoms of the same element are not always identical.

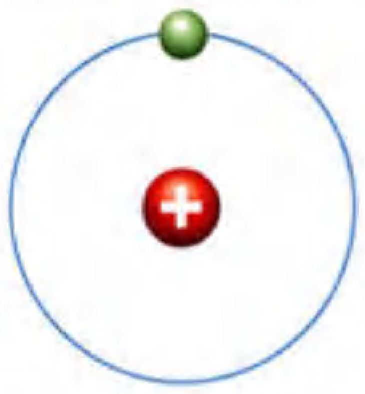
- Atoms of the same element have the same number of protons.
- They may differ in the number of neutrons.
- Therefore, they may have different mass numbers.

DEFINITION

Isotopes: forms of the same element that have the same atomic number and different mass numbers.

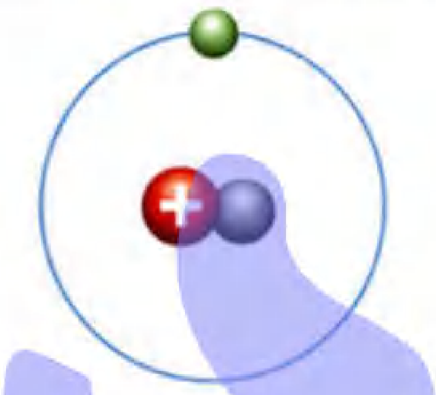
Hydrogen isotopes

A Protium (^1H)



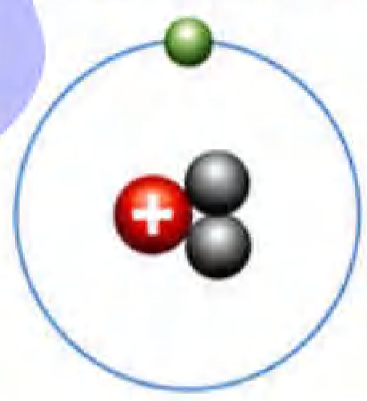
Protons = 1
Neutrons = 0
Mass number = 1

B Deuterium (^2H)



Protons = 1
Neutrons = 1
Mass number = 2

C Tritium (^3H)



Protons = 1
Neutrons = 2
Mass number = 3

All three hydrogen isotopes have the same atomic number (1) because they each have one proton. They differ in the number of neutrons and mass numbers.

HOW THE HYDROGEN ISOTOPES DIFFER

Isotope	Atomic number (Z)	Mass number (A)	Protons	Neutrons
Protium	1	1	1	0
Deuterium	1	2	1	1
Tritium	1	3	1	2

- Isotopes belong to the same element because they have the same number of protons.
- Different numbers of neutrons make their mass numbers different.

LESSON REVIEW

Matter is built from atoms.

The atom contains protons, neutrons, and electrons.

Na
Each element has a chemical symbol.

12
6
Atomic number and mass number describe the atom.

Electrons are distributed in energy levels.

Isotopes are atoms of the same element with different mass numbers.

PERIODIC TABLE

Lesson 2 | The Journey to the Modern Periodic Table

Science Field: Materials Science

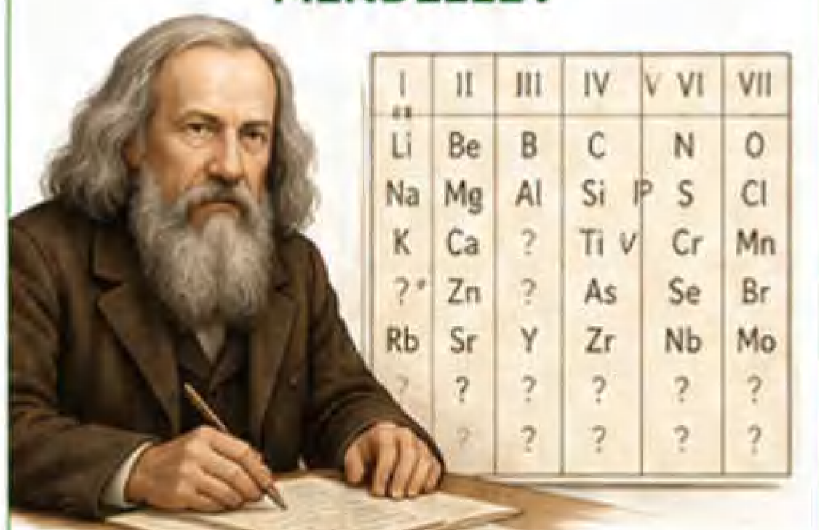
Topic: Development of the Periodic Table

KEY CONCEPT

Scientists tried to classify elements because the number of known elements increased and their physical and chemical properties needed an organised system.

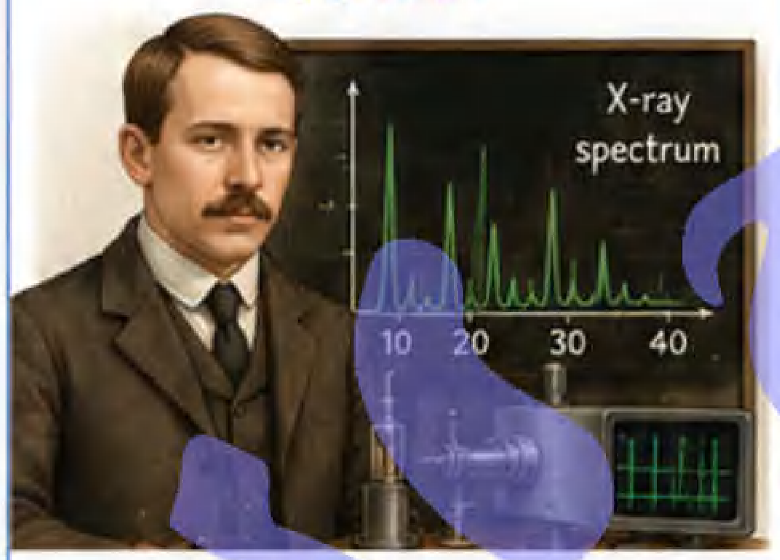
THE JOURNEY TO THE MODERN PERIODIC TABLE

1 MENDELEEV


I
II
III
IV
V
VI
VII
Li Be B C N O
Na Mg Al Si P S Cl
K Ca ? Ti V Cr Mn
?* Zn ? As Se Br
Rb Sr Y Zr Nb Mo
? ? ? ? ? ?

- Arranged elements in increasing atomic mass.
- Discovered that properties repeat periodically.
- Left gaps for elements not yet discovered.

2 MOSELEY



- Arranged elements in increasing atomic number.
- Corrected the order of some elements.
- Helped establish a more accurate table.

3 MODERN PERIODIC TABLE

- The modern table arranges elements by increasing atomic number.
- It reflects their electron arrangement more accurately.

BASIS OF CLASSIFICATION

Stage	Mendeleev	Moseley	Modern Periodic Table
Basis	Atomic mass	Atomic number	Atomic number and electron arrangement

IMPORTANT NOTE

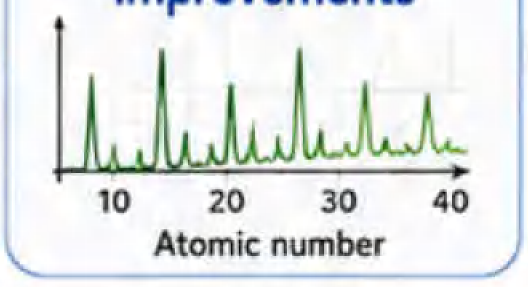
The modern periodic table is the result of developing earlier attempts to classify elements.

FROM PAST IDEAS TO TODAY'S TABLE

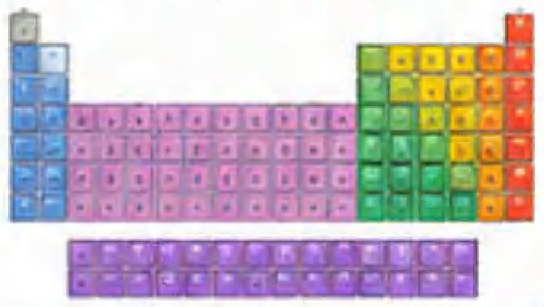
Early attempts

Mendeleev's table

Moseley's improvements



Modern periodic table



PERIODIC TABLE

Lesson 2 | The Modern Periodic Table

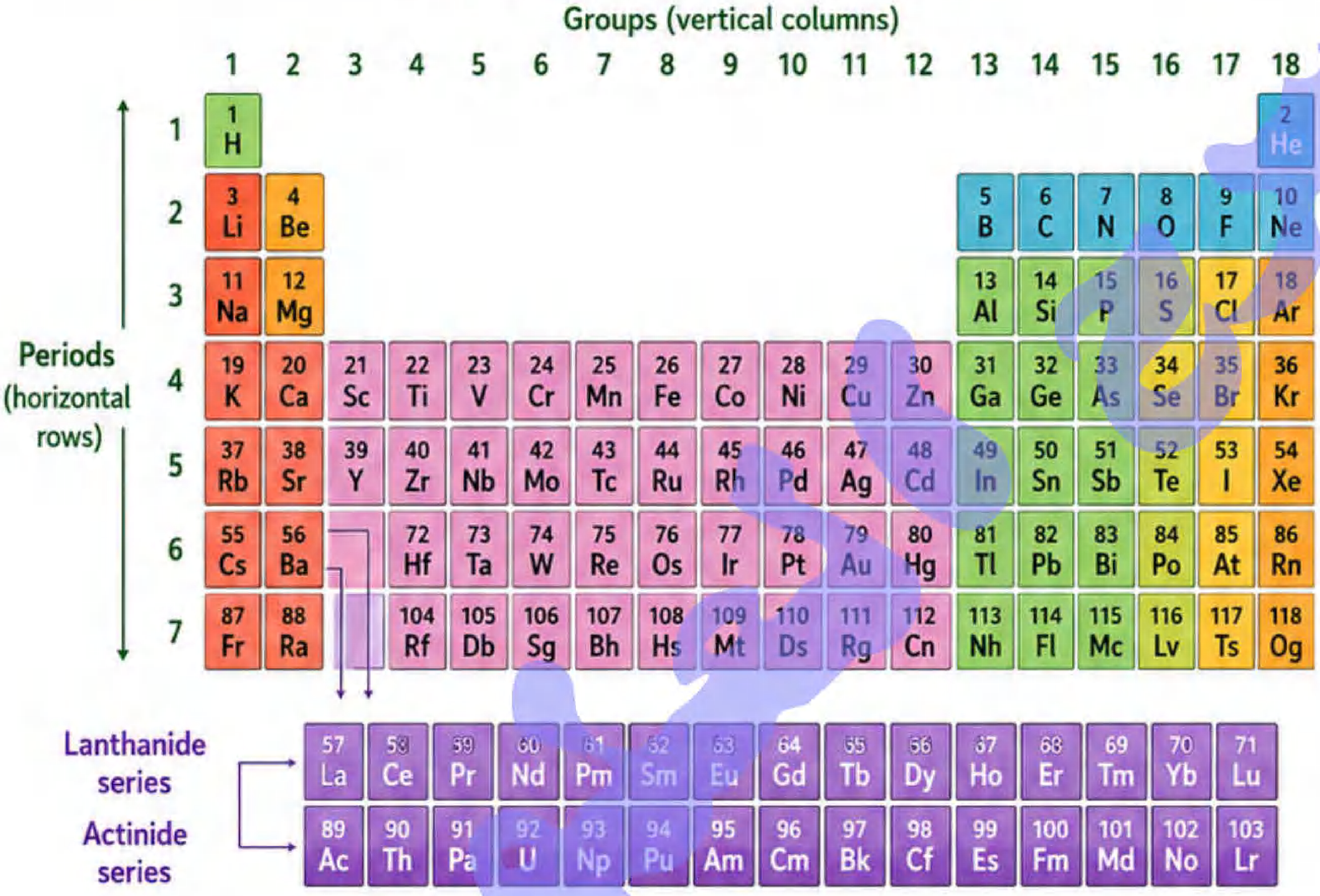
Science Field: Materials Science

Topic: Structure of the Modern Periodic Table

KEY CONCEPT

The modern periodic table arranges elements in increasing atomic number.

THE MODERN PERIODIC TABLE



Groups (vertical columns)

Periods (horizontal rows)

Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

Lanthanide series	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
Actinide series	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

DESCRIPTION OF THE MODERN TABLE

- ✓ 7 horizontal periods.
- ✓ 18 vertical groups.
- ✓ 118 known elements.

PERIODS IN THE MODERN TABLE

A new period begins when electrons start to occupy a new main energy level.

A period ends when that energy level is completed.

NUMBER OF ELEMENTS IN THE FIRST FOUR PERIODS

Period	1	2	3	4
Number of elements	2	8	8	18

REMEMBER

The position of an element in the modern periodic table helps scientists describe and compare elements.

AT A GLANCE: THE STRUCTURE OF THE MODERN PERIODIC TABLE

Periods
Horizontal rows
(1 to 7)

Groups
Vertical columns
(1 to 18)

Modern table
Arranges elements in increasing atomic number. It has 118 elements.

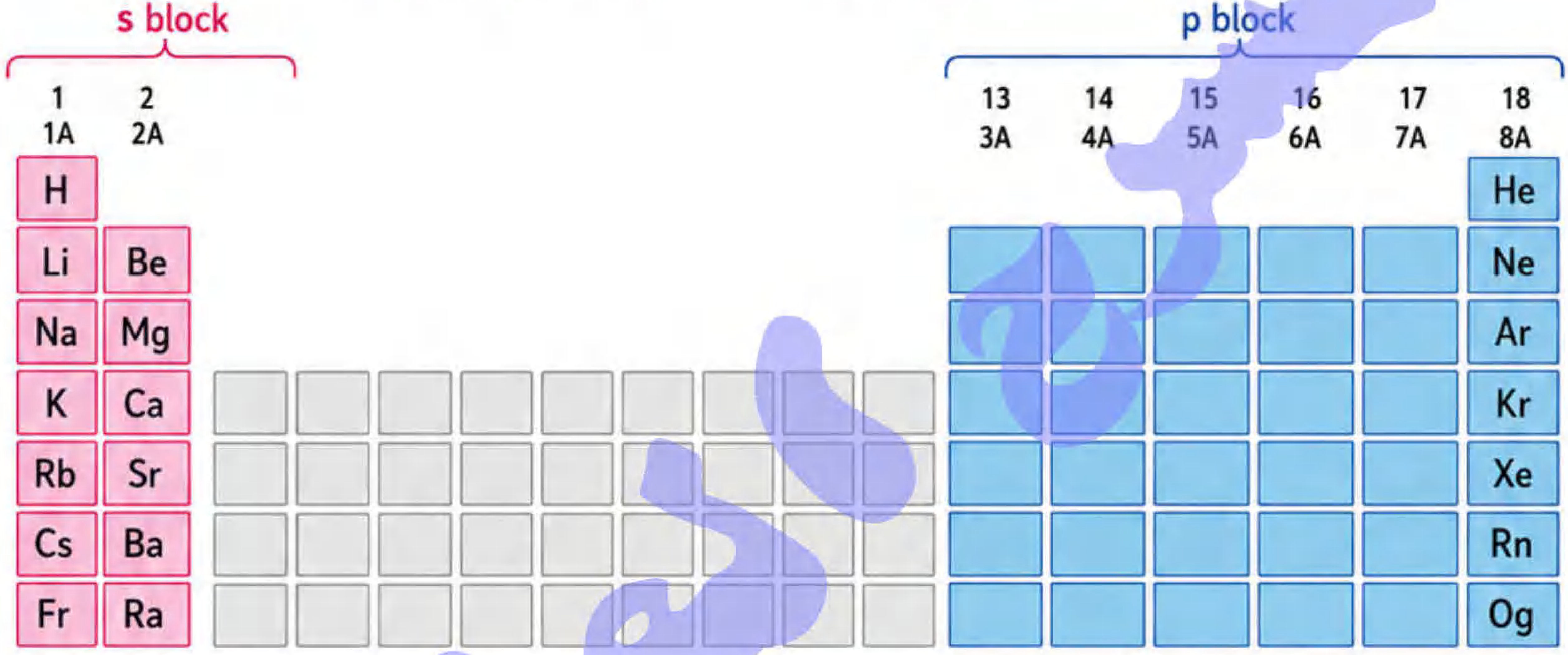
Science Field:
Materials Science

Topic:
Blocks of the Modern Periodic Table

KEY CONCEPT

The modern periodic table can be divided into blocks according to the part of the table occupied by the elements.

THE s AND p BLOCKS IN THE MODERN PERIODIC TABLE



s BLOCK

- It occupies the left side of the modern periodic table.
- It consists of two groups.
- Most of its elements are metals, except hydrogen.
- It includes Group 1A and Group 2A.

p BLOCK

- It occupies the right side of the modern periodic table.
- Its elements include metals, non-metals, metalloids, and noble gases.
- It starts with Group 3A and ends with Group 18.

OLD AND MODERN GROUP LABELS FOR THE s AND p BLOCKS

s Block (Left Side)

Old group labels	1A	2A
Modern group numbers	1	2

p Block (Right Side)

Old group labels	3A	4A	5A	6A	7A	8A
Modern group numbers	13	14	15	16	17	18

REMEMBER

The s block and p block together contain many of the best-known main-group elements.

PERIODIC TABLE

Lesson 2 | The d and f Blocks

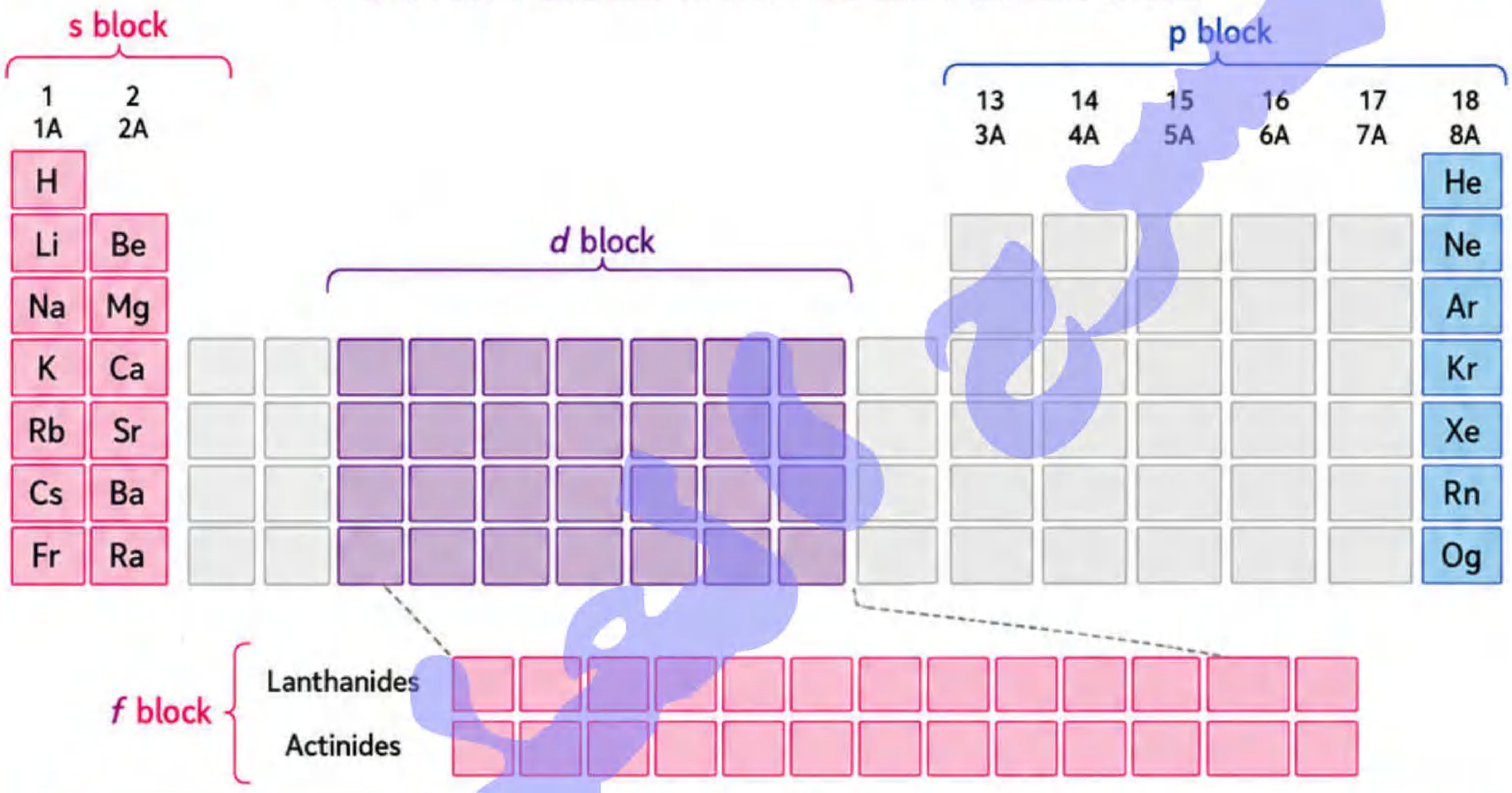
Science Field:
Materials Science

Topic:
Transition and Inner Transition Elements

KEY CONCEPT

The middle and bottom parts of the modern periodic table contain the d and *f* blocks.

THE d AND *f* BLOCKS IN THE MODERN PERIODIC TABLE


s block
1
1A
2
2A
H
Li
Be
Na
Mg
K
Ca
Rb
Sr
Cs
Ba
Fr
Ra
d block
p block
13
3A
14
4A
15
5A
16
6A
17
7A
18
8A
He
Ne
Ar
Kr
Xe
Rn
Og
f block
Lanthanides
Actinides

d BLOCK

- It occupies the middle of the modern periodic table.
- It includes the transition elements.
- Its elements are all metals.
- It forms ten groups.

f BLOCK

- It occupies the bottom of the modern periodic table.
- It consists of two series: lanthanides and actinides.
- Its elements are called inner transition elements.

LANTHANIDES AND ACTINIDES

Lanthanides (57–71)	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Actinides (89–103)	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

- Lanthanides: 15 elements. They follow lanthanum (La).
- Actinides: 15 elements. They follow actinium (Ac).

REMEMBER

The *d* and *f* blocks are important metallic regions of the periodic table.

PERIODIC TABLE

Lesson 2 | Types of Elements and Important Groups

Science Field: Materials Science

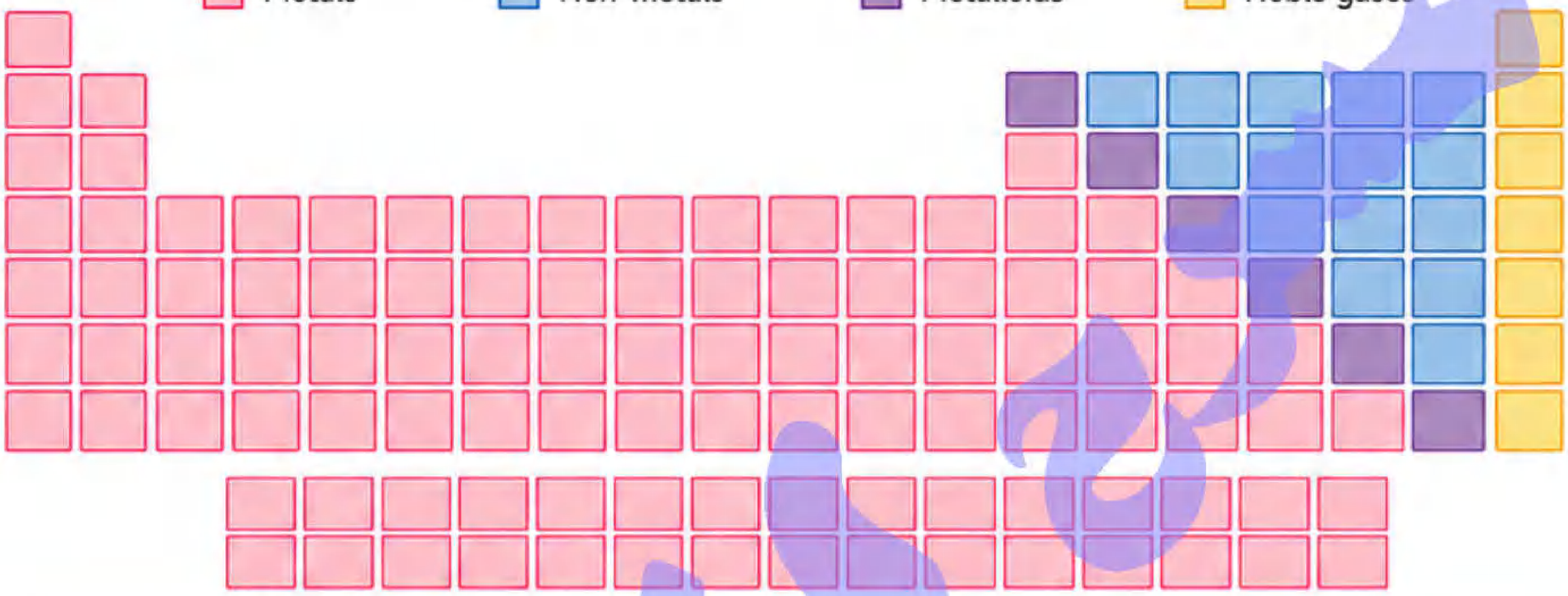
Topic: Classification of Elements in the Modern Table

KEY CONCEPT

The elements in the modern periodic table can be classified into metals, non-metals, metalloids, and noble gases.

CLASSIFICATION MAP OF ELEMENTS

🟥 Metals 🟦 Non-metals 🟪 Metalloids 🟨 Noble gases



METALS

- Usually have 1, 2, or 3 electrons in the outermost level.
- Occupy most regions of the table.

NON-METALS

- Usually have 4, 5, 6, or 7 electrons in the outermost level.
- Occupy the right side of the table.

METALLOIDS

- Lie along the zigzag line between metals and non-metals.

NOBLE GASES

- Are in Group 18.
- Have a complete outermost energy level, except helium which has 2 electrons.

IMPORTANT GROUPS

GROUP 1A
Alkali Metals

- Block: s-block
- Outermost electrons: 1
- Very reactive metals; react vigorously with water to form alkaline solutions.

GROUP 2A
Alkaline Earth Metals

- Block: s-block
- Outermost electrons: 2
- Reactive metals; less reactive than Group 1A metals; form basic oxides.

GROUP 7A / 17
Halogens

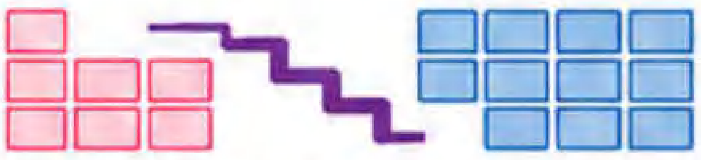
- Block: p-block
- Outermost electrons: 7
- Very reactive non-metals; react with metals to form salts (halides).

GROUP 18
Noble Gases

- Block: p-block
- Outermost electrons: 8 (except He: 2)
- Very stable and unreactive due to complete outermost energy level.

CAUTION:

Metalloids cannot be identified from electron distribution alone.
Their properties are intermediate between metals and non-metals.



REMEMBER

The classification of elements depends on both their position in the periodic table and their electronic structure.

PERIODIC TABLE

Lesson 2 | Electron Distribution and Periodic Position

Science Field: Materials Science

Topic: Relation Between Electron Distribution and Position

KEY CONCEPT

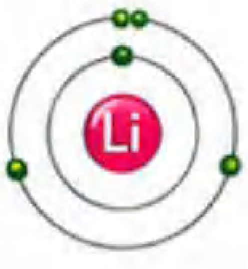
The electron distribution of an element helps determine its group and period.

1) ELEMENTS IN THE SAME GROUP

Elements in the same group have the same number of electrons in the outermost energy level.

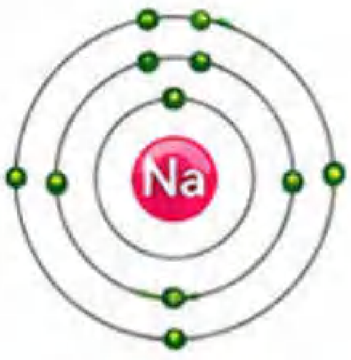
GROUP 1A (Alkali Metals)

Lithium (Li) 3



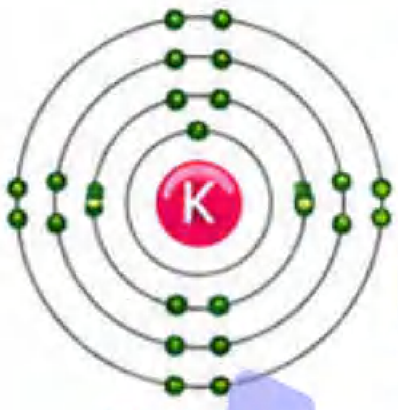
Distribution: 2, 1

Sodium (Na) 11



Distribution: 2, 8, 1

Potassium (K) 19

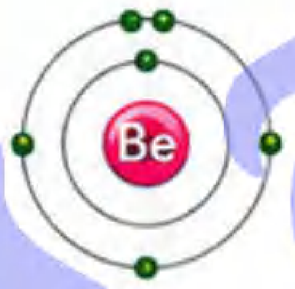


Distribution: 2, 8, 8, 1

All have 1 electron in the outermost level.

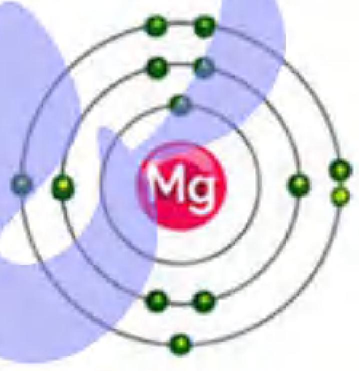
GROUP 2A (Alkaline Earth Metals)

Beryllium (Be) 4



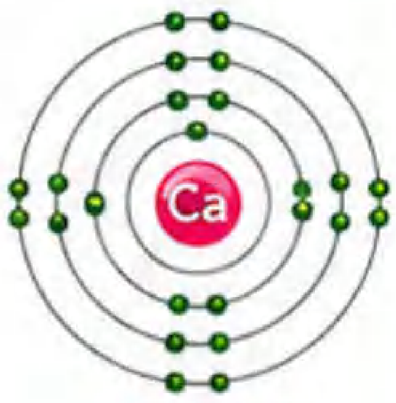
Distribution: 2, 2

Magnesium (Mg) 12



Distribution: 2, 8, 2

Calcium (Ca) 20



Distribution: 2, 8, 8, 2

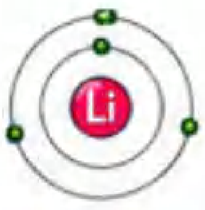
All have 2 electrons in the outermost level.

2) ELEMENTS IN THE SAME PERIOD

Elements in the same period have the same number of occupied energy levels (electron shells).

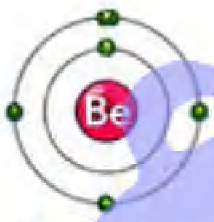
EXAMPLE: PERIOD 2

Lithium (Li) 3



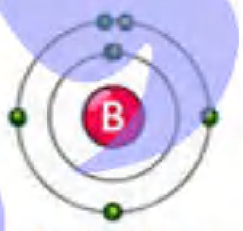
Distribution: 2, 1

Beryllium (Be) 4



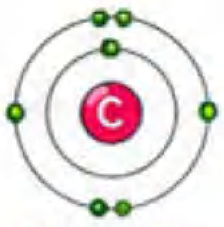
Distribution: 2, 2

Boron (B) 5



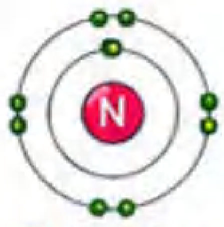
Distribution: 2, 3

Carbon (C) 6



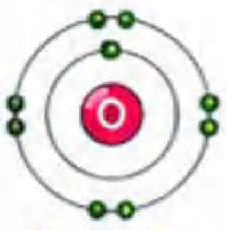
Distribution: 2, 4

Nitrogen (N) 7



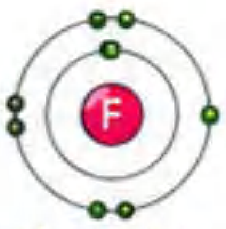
Distribution: 2, 5

Oxygen (O) 8



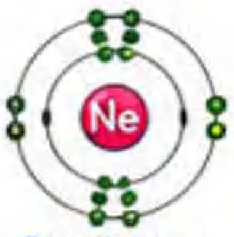
Distribution: 2, 6

Fluorine (F) 9



Distribution: 2, 7

Neon (Ne) 10



Distribution: 2, 8

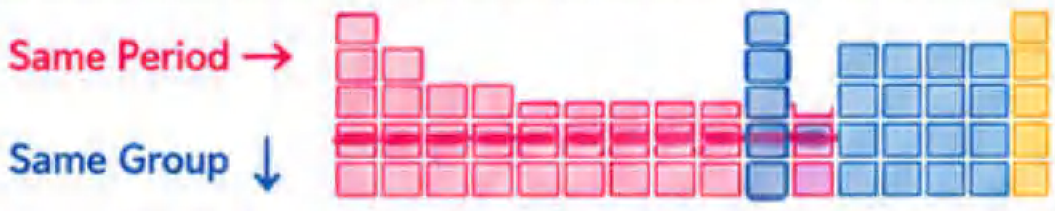
All these elements have two occupied energy levels (n = 2).

QUICK COMPARISON

SAME GROUP	SAME PERIOD
Elements have the same number the outermost electrons. → They show similar chemical properties.	Elements have the same number occupied energy levels. → Properties change gradually across the period.

THINK AND OBSERVE

The position of an element in the periodic table is closely linked to how its electrons are arranged.



PERIODIC TABLE

Lesson 2 | Finding an Element's Position

Science Field: Materials Science

Topic: Determining Period, Group, and Block

KEY CONCEPT

An element's period, group, and block can be found from its electron distribution.

1) HOW TO DETERMINE THE POSITION OF AN ELEMENT

COUNT THE OCCUPIED ENERGY LEVELS

Count the number of energy levels that have electrons.

This gives the **PERIOD NUMBER.**

→

2 COUNT THE ELECTRONS IN THE OUTERMOST LEVEL

Count the electrons in the outermost (highest) energy level.

For MAIN-GROUP ELEMENTS, this gives the **GROUP.**

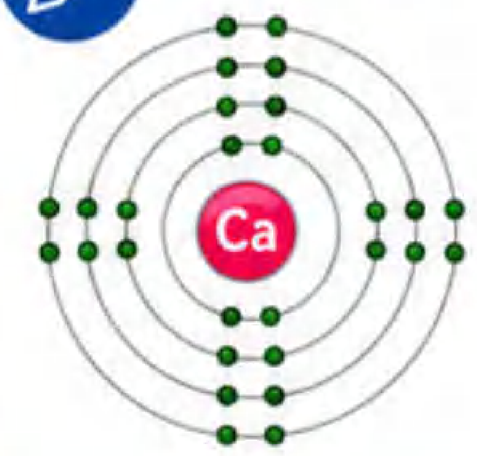
→

3 IDENTIFY THE BLOCK

Use the position of the electrons in the outermost energy level to identify the block.

Main-group elements are in either the **s** block or **p** block.

2) WORKED EXAMPLE: CALCIUM (Ca)



Electron distribution:

2, 8, 8, 2

1. Occupied energy levels: 2, 8, 8, 2 → 4 levels → **Period 4**
2. Outermost electrons: 2 electrons → **Group 2A**
3. Block: Outermost electrons are in the s subshell ($4s^2$). → **s block**

Therefore, **Calcium (Ca)** is located in:

Period 4

Group 2A

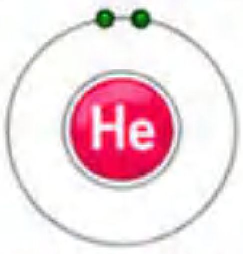
s block

3) COMPARISON: LOCATING DIFFERENT ELEMENTS

Element	Electron Distribution	Occupied Levels	Period	Outermost Electrons	Group (Main Group)	Block
H	2	1	1	1	1A	s block
Na	2, 8, 1	3	3	1	1A	s block
Mg	2, 8, 2	3	3	2	2A	s block
O	2, 6	2	2	6	6A	p block
Ar	2, 8, 8	3	3	8	8A (18)	p block

4) SPECIAL CASE: HELIUM (He)

Helium has 2 electrons in the first energy level (distribution: 2). Although it has a full first level, it belongs to **GROUP 18** (noble gases), not Group 2A.



Helium is unique!
2 electrons → Period 1,
but Group 18.

REMEMBER

The arrangement of **electrons in energy levels** is the **key** to locating any element in the periodic table.

PERIODIC TABLE

Lesson 2 | Atomic Number Patterns

Science Field: Materials Science

Topic: Using Position to Determine Atomic Number

KEY CONCEPT

The atomic number of an element equals the number of electrons in a neutral atom. It increases in a regular pattern across and down the periodic table.

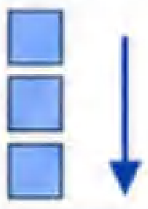
MAIN RULES

1 ACROSS A PERIOD

Atomic number increases by 1 from left to right.

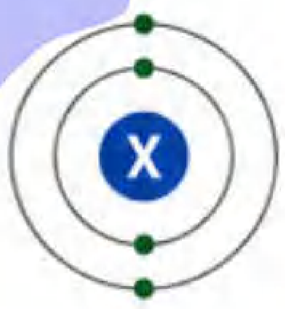
2 DOWN A GROUP

Atomic number increases as we move downward.



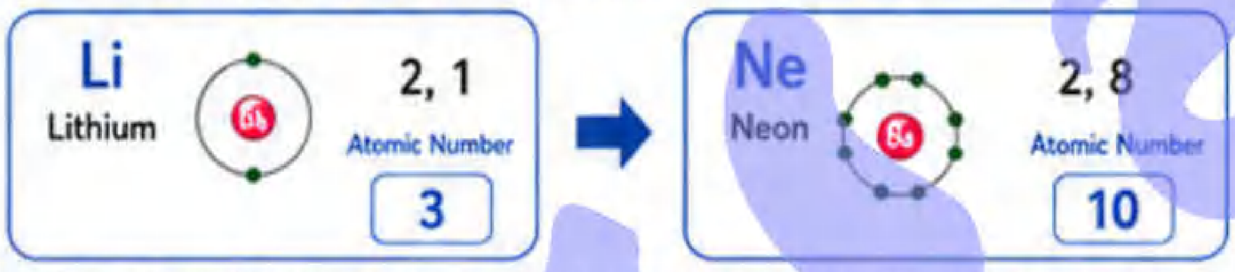
3 NEUTRAL ATOM RULE

For a neutral atom, ATOMIC NUMBER = TOTAL NUMBER OF ELECTRONS.



1) WORKED EXAMPLE: HOW ATOMIC NUMBERS PROGRESS

Across Period 2 (Left → Right)

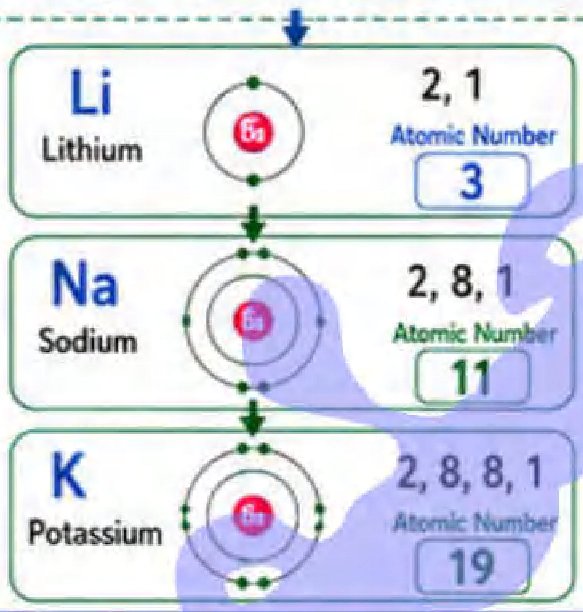


Li Lithium 2, 1 Atomic Number 3

Ne Neon 2, 8 Atomic Number 10

From Li (3) to Ne (10), atomic number increases by 1 across the period.

Down Group 1A (Top → Down)

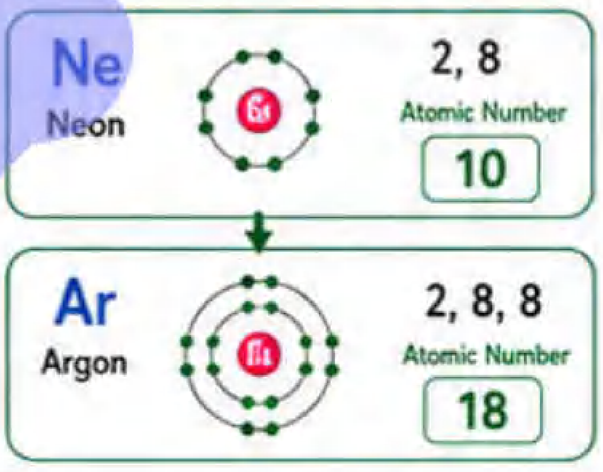


Li Lithium 2, 1 Atomic Number 3

Na Sodium 2, 8, 1 Atomic Number 11

K Potassium 2, 8, 8, 1 Atomic Number 19

Down Group 18 (Noble Gases)



Ne Neon 2, 8 Atomic Number 10

Ar Argon 2, 8, 8 Atomic Number 18

From Ne (10) to Ar (18), atomic number increases down the group.

2) HOW TO FIND ATOMIC NUMBER FROM ELECTRON DISTRIBUTION

Add the electrons in all occupied levels.

Example 1

Electron distribution:
2, 7
2 + 7 = 9
Atomic Number = 9

Example 2

Electron distribution:
2, 8, 8
2 + 8 + 8 = 18
Atomic Number = 18

3) DEDUCTION: FIND THE ATOMIC NUMBER

1	An element is in Period 2, Group 7A.	Step 1: Period 2 → two levels → 2 Step 2: Group 7A → 7 valence e⁻	Atomic Number 9
2	An element is in Period 3, Group 18.	Step 1: Period 3 → three levels → 2, 8, ... Step 2: Group 18 → 8 valence e⁻	Atomic Number 18
3	An element is in Period 4, Group 2A.	Step 1: Period 4 → four levels → 2, 8, 8, ... Step 2: Group 2A → 2 valence e⁻	Atomic Number 20

REMEMBER

Position in the periodic table and electron arrangement work together to reveal the atomic number of every element.

PERIODIC TABLE

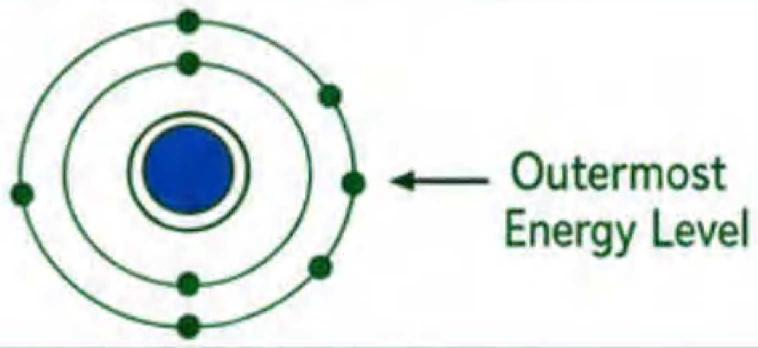
Lesson 2 | Valency and Lewis Dot Symbols

Science Field:
Materials Science

Topic:
Valency from Outermost Electrons

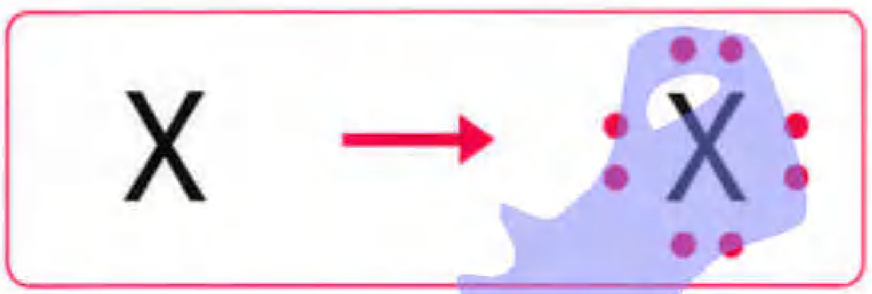
1) KEY CONCEPT

Valency depends on the electrons in the outermost energy level.



2) G. N. LEWIS & LEWIS DOT SYMBOLS

G. N. Lewis proposed that electrons in the outermost energy level of an atom can be shown around the element symbol as dots.
These are called Lewis dot symbols.

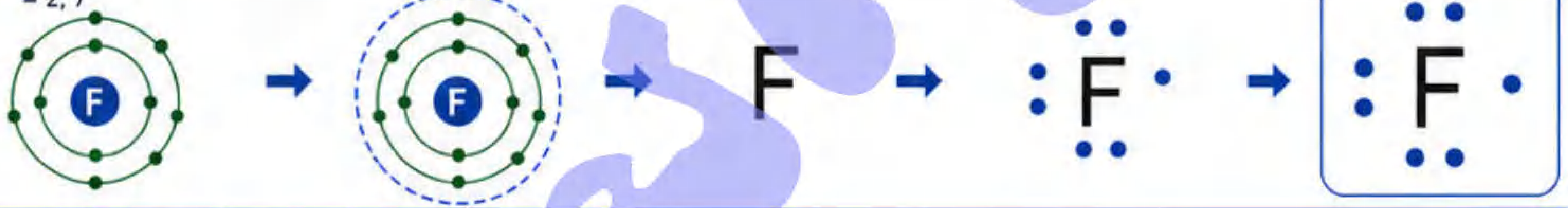


3) RULE:

1. Valency of the element is related to the outermost electrons.
2. In a Lewis dot symbol, the unpaired outermost electrons help indicate valency.

4 WORKED EXAMPLE: FLUORINE (F)

1. Fluorine (F)
   Atomic Number = 9
   Electron distribution = 2, 7
2. Outermost (valence) electrons = 7
3. Write the symbol of the element.
4. Place 7 dots around the symbol.
5. Final Lewis dot symbol of Fluorine.



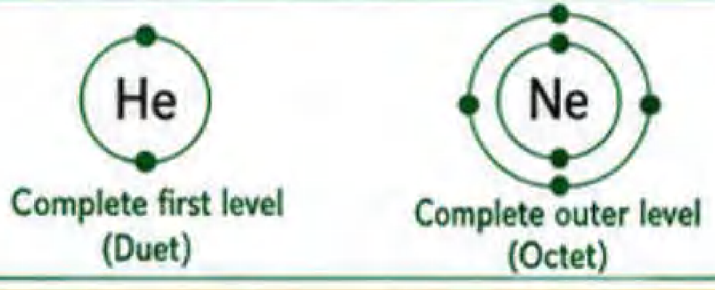
Conclusion: Fluorine has 7 valence electrons. It needs 1 electrons to complete an octet. Therefore, the valency of Fluorine is 1.

5 SUMMARY TABLE: REPRESENTATIVE ELEMENTS

Element	Group (IUPAC)	Electron Distribution (K, L, M)	Lewis Dot Symbol	Valency
Na (Sodium)	1	2 , 8 , 1	Na •	1
Mg (Magnesium)	2	2 , 8 , 2	• Mg •	2
Al (Aluminum)	13	2 , 8 , 3	• Al ••	3
Si (Silicon)	14	2 , 8 , 4	• Si •••	4
P (Phosphorus)	15	2 , 8 , 5	•• P ••	3
S (Sulfur)	16	2 , 8 , 6	⁚ S ⁚	2
Cl (Chlorine)	17	2 , 8 , 7	•• Cl ⁚	1
Ar (Argon)	18	2 , 8 , 8	∷ Ar ∷	0

6) NOTE: NOBLE GASES

Noble gases have valency zero because their outermost energy levels are complete (octet complete). Helium is a special case with a complete first energy level (duet).



Complete first level (Duet)

Complete outer level (Octet)

7) REMEMBER

Lewis symbols give a quick picture of the valence electrons in an atom and help us determine its valency easily.

PERIODIC TABLE

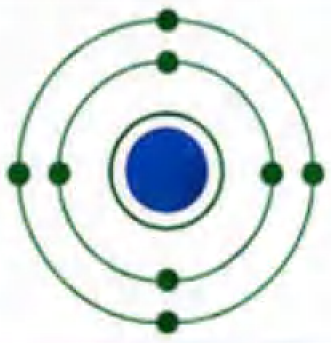
Lesson 2 | Periodic Trends and Review

Science Field: Materials Science

Topic: Properties of Elements in the Periodic Table

1) KEY CONCEPT

An element's chemical and physical properties are related to its position in the periodic table and to its electron arrangement.



← **Electron arrangement** determines how an element behaves and reacts.

2) CHEMICAL ACTIVITY

Group 1 (Alkali Metals)

Chemical activity **increases** down the group.

	Examples
Li	Lithium
Na	Sodium
K	Potassium
Rb	Rubidium
Cs	Cesium
Fr	Francium

Group 7 (Halogens)

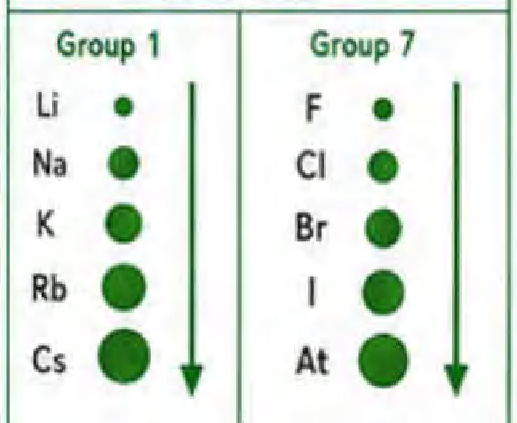
Chemical activity **decreases** down the group.

	Examples
F	Fluorine
Cl	Chlorine
Br	Bromine
I	Iodine
At	Astatine
Ts	Tennessine

3) PHYSICAL PROPERTIES

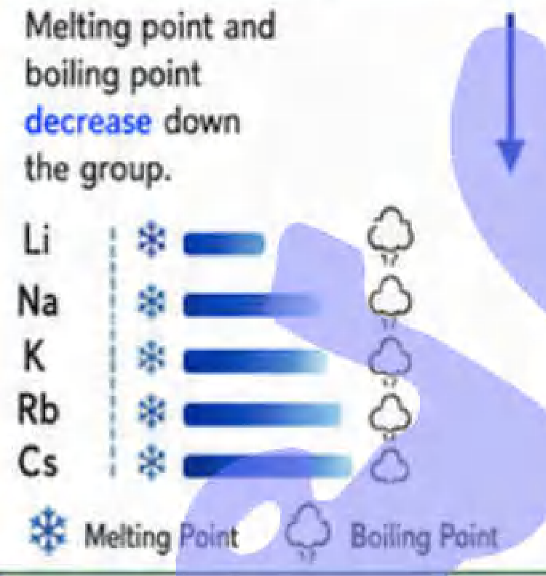
Atomic Radius

Atomic radius increases down Group 1 and down Group 7.



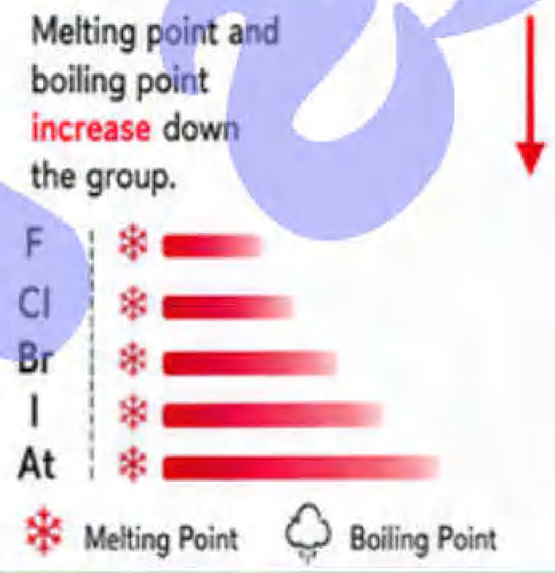
Group 1: Melting Point and Boiling Point

Melting point and boiling point **decrease** down the group.



Group 7: Melting Point and Boiling Point

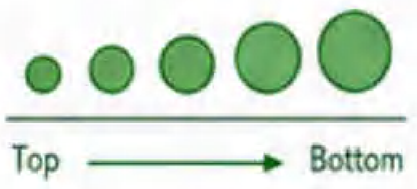
Melting point and boiling point **increase** down the group.



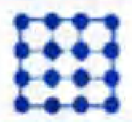
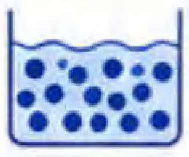
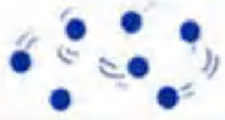
General Trend Summary

Atomic radius increases down groups.

Melting/boiling points:
Group 1 decrease ↓
Group 7 increase ↑



4) PHYSICAL STATE AT 25°C (ROOM TEMPERATURE)

Condition	Rule	State	Diagram
If melting point is higher than 25°C.	Melting Point (MP) > 25°C	Solid	
If melting point is lower than 25°C and boiling point is higher than 25°C.	Melting Point (MP) < 25°C and Boiling Point (BP) > 25°C	Liquid	
If boiling point is lower than 25°C.	Boiling Point (BP) < 25°C	Gas	

EXAMPLES: ELEMENTS BY STATE AT 25 °C

Solids	Carbon (C), Sulfur (S), Magnesium (Mg), Copper (Cu), Gold (Au) and most metals and non-metals are solids.
Liquids	Mercury (Hg) and Bromine (Br) are liquids at 25°C.
Gases	Hydrogen (H_2), Nitrogen (N_2), Oxygen (O_2), Fluorine (F_2), Chlorine (Cl_2) and All noble gases (He, Ne, Ar, Kr, Xe, Rn) are gases at 25°C.

6) LESSON REVIEW: WHAT WE LEARNED

1. **Classification Attempts** – *Early scientists tried to classify elements by property.* →
2. **Modern Periodic Table** – *Arranged by atomic number and recurring properties.* →
3. **Blocks (s, p, d, f)** – Elements are grouped into blocks based on their valence electron subshell. s p d f →
4. **Groups** – Vertical columns with similar outer electron arrangement. →
5. **Electron Distribution** – Outermost electrons determine valency and chemical behavior. →
6. **Valency & Trends** – Trends in reactivity, atomic size, and melting/boiling points help predict properties.

7) REMEMBER

Periodic trends help us predict how elements behave, react, and what properties they have.

MATTER AND ITS PROPERTIES

Lesson 3 | Classification of Materials

Science Field: Materials Science

Topic: Classification of Materials

KEY CONCEPT Materials can be classified into mixtures and pure substances.

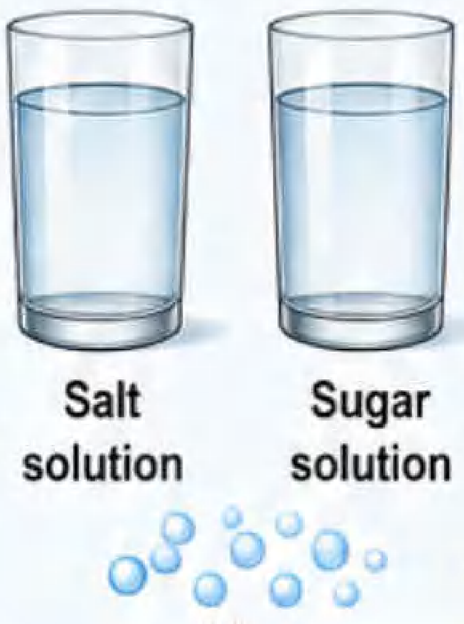
Materials

Mixtures

Homogeneous Mixtures

The components are evenly distributed and cannot be distinguished by the naked eye.

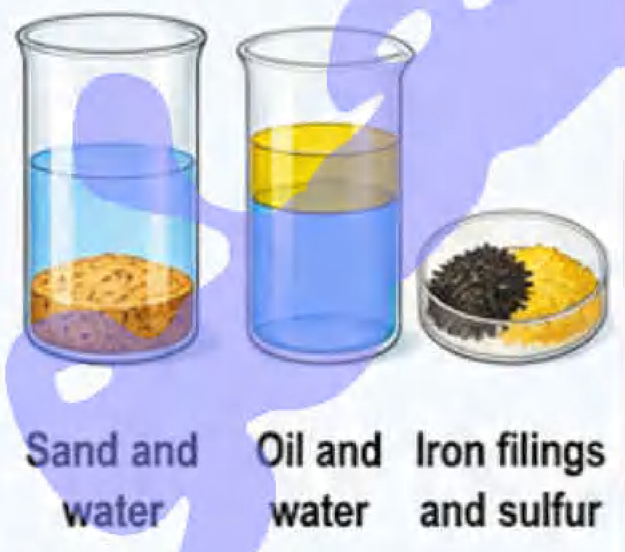
Examples


Salt solution
Sugar solution
Air

Heterogeneous Mixtures

The components are not evenly distributed and can be distinguished by the naked eye.

Examples

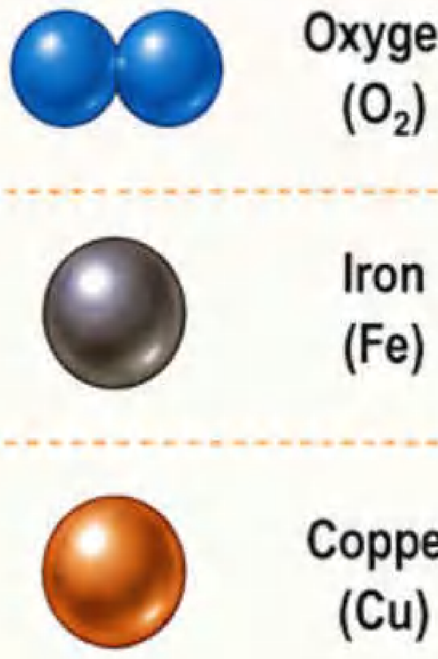

Sand and water
Oil and water
Iron filings and sulfur

Pure Substances

Elements

A pure substance made of only one kind of atom.

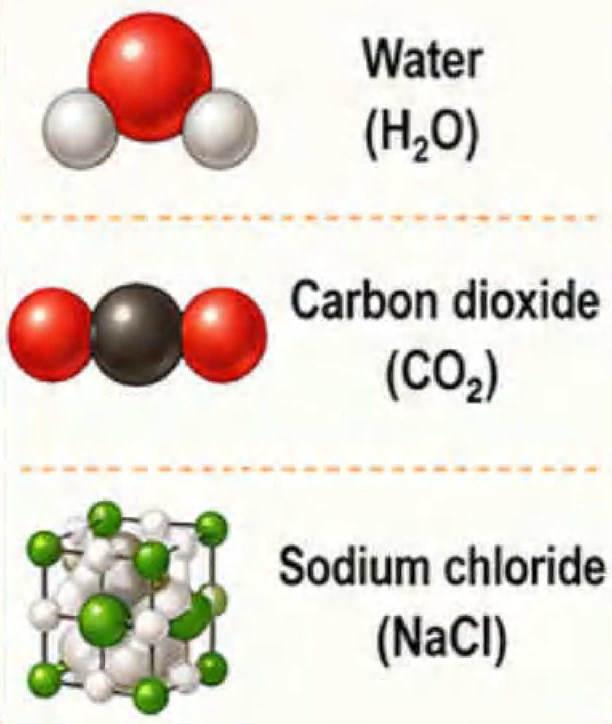
Examples


Oxygen (O_2)
Iron (Fe)
Copper (Cu)

Compounds

A pure substance formed when two or more elements combine chemically in a fixed ratio.

Examples


Water (H_2O)
Carbon dioxide (CO_2)
Sodium chloride (NaCl)

Quick Comparison

Mixtures	Can often be separated by physical methods.
Pure substances	Cannot be separated into components by simple physical methods.

Remember

- ★ Homogeneous mixtures look uniform.
- ★ Heterogeneous mixtures do not.
- ★ Pure substances include elements and compounds.

MATTER AND ITS PROPERTIES

Lesson 3 | Separating Mixtures

Science Field: Materials Science

Topic: Separation Methods for Mixtures

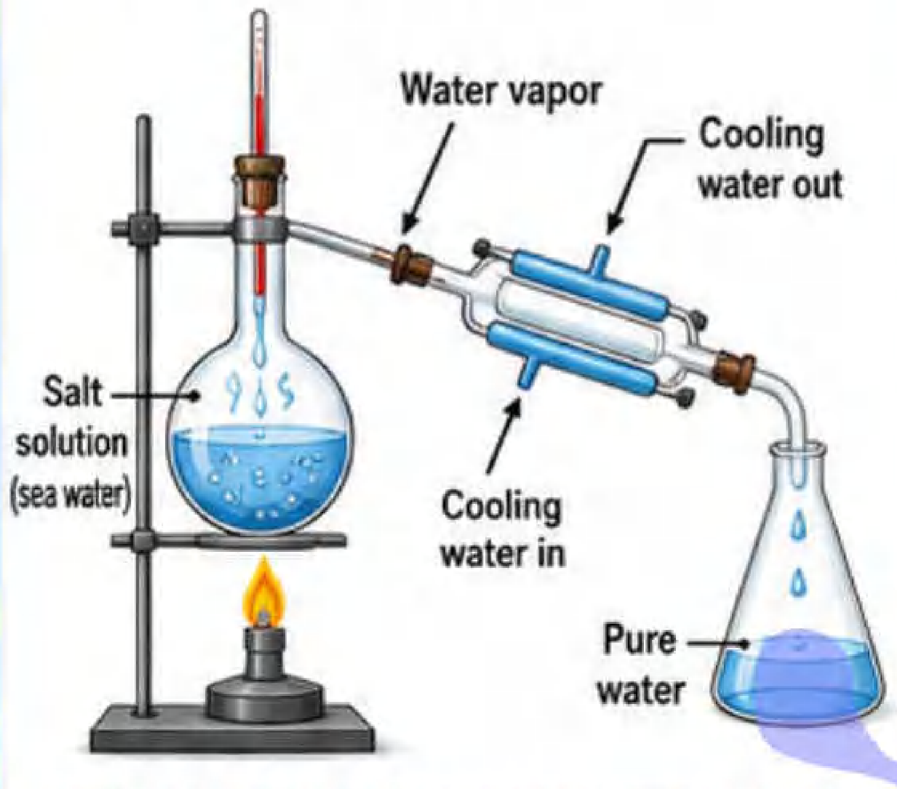
KEY CONCEPT Mixtures can be separated by physical methods because their components are not chemically combined.

Common Methods for Separating Mixtures

1 Distillation

Used to separate a homogeneous mixture when one component is a liquid that can evaporate and condense.

Example: Obtaining pure water from salt solution (sea water).


Water vapor
Cooling water out
Salt solution (sea water)
Cooling water in
Pure water

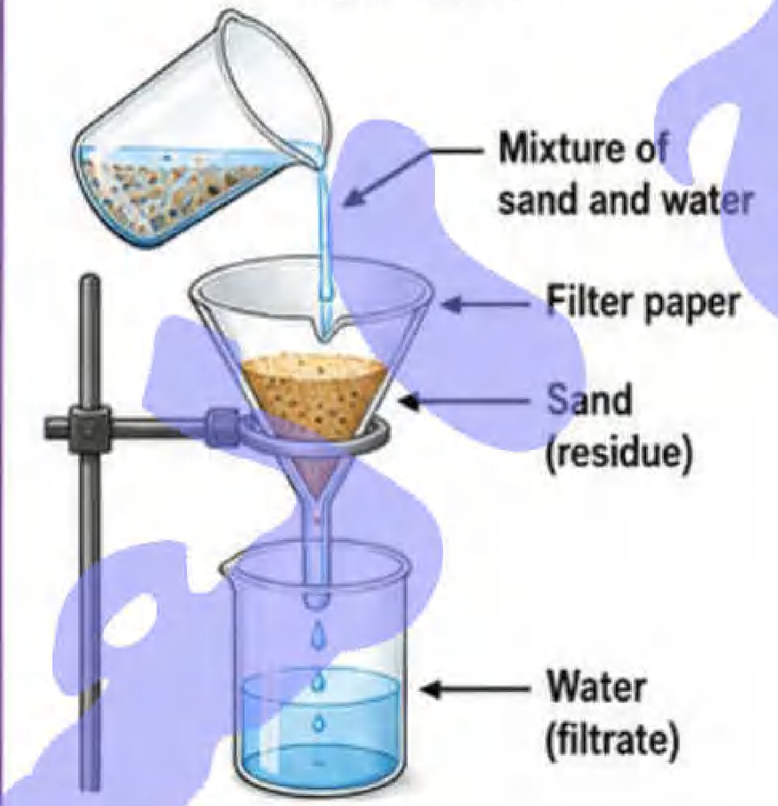
1. Heat the mixture.
2. Water evaporates first.
3. Water vapor condenses.
4. Pure water is collected.
5. Salt remains behind.

✓ Suitable for homogeneous mixtures.

2 Filtration

Used to separate an insoluble solid from a liquid in a heterogeneous mixture.

Example: Separating sand from water.


Mixture of sand and water
Filter paper
Sand (residue)
Water (filtrate)

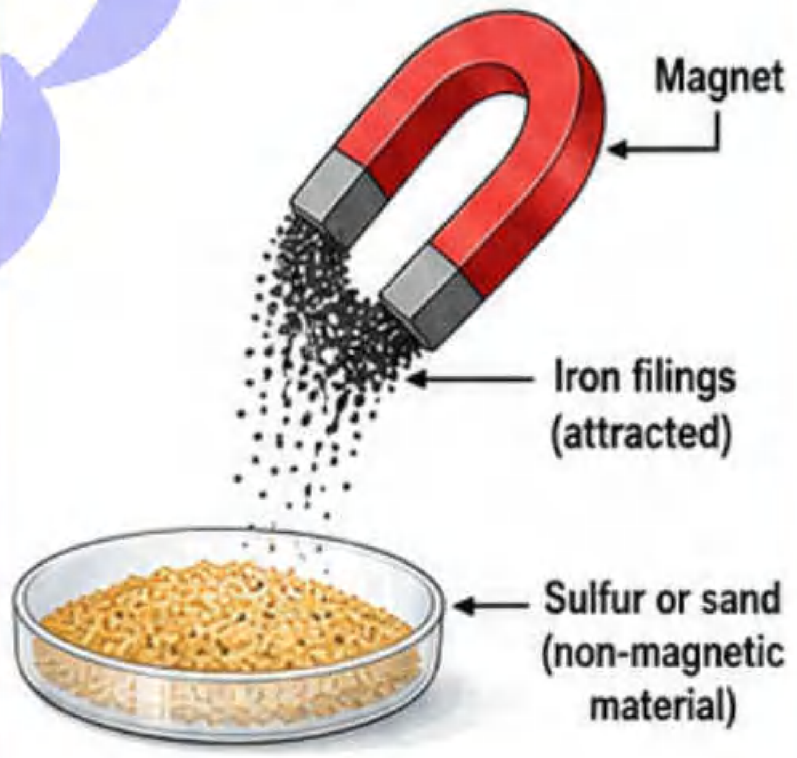
1. Pour the mixture into the funnel.
2. Sand remains on the filter paper.
3. Water passes through as the filtrate.

✓ Suitable for heterogeneous mixtures.

3 Magnetic Separation

Used to separate a magnetic substance from a non-magnetic substance.

Example: Separating iron filings from sulfur or sand.


Magnet
Iron filings (attracted)
Sulfur or sand (non-magnetic material)

1. Bring a magnet near the mixture.
2. Iron filings are attracted.
3. The non-magnetic material remains.

✓ Suitable when one component is magnetic.

How Do I Choose the Method?

Distillation

Choose when there is a difference in boiling behavior (one liquid evaporates and condenses).

Filtration

Choose when the mixture has an insoluble solid and a liquid.

Magnetic separation

Choose when one component of the mixture is magnetic and the other is not.

Remember

A mixture is separated physically.

No new substance is formed.

Lesson 3 | Pure Substances: Elements and Compounds

Science Field: Materials Science | **Topic:** Pure Substances

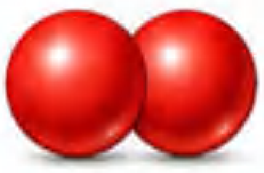
KEY CONCEPT Pure substances include elements and compounds.

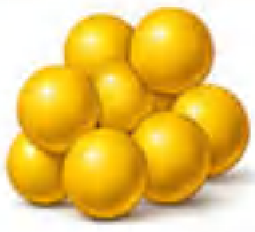
Elements

An element is a pure substance that contains only one kind of atom.

IMPORTANT POINT
It cannot be broken down into simpler substances by physical or ordinary chemical means.

Examples


Oxygen (O_2)


Sulfur (S)

Iron (Fe)

Mercury (Hg)

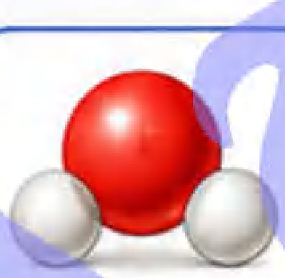
★ All atoms in an element are of the same type.

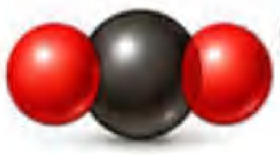
Compounds

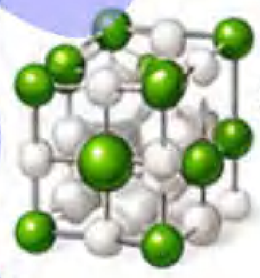
A compound is a pure substance formed when two or more elements combine chemically in a fixed ratio.

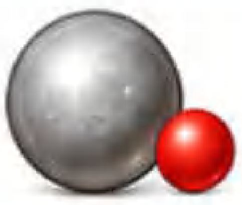
IMPORTANT POINT
A compound can be decomposed only by chemical methods.

Examples


Water (H_2O)


Carbon dioxide (CO_2)


Sodium chloride (NaCl)


Mercury oxide (HgO)

★ The properties of a compound are different from the properties of its elements.

Element vs Compound

Aspect	Element	Compound
Composition	One type of atom.	Two or more elements chemically combined.
Type of atoms present	Same atoms.	Different atoms.
Can it be decomposed?	Not into simpler substances.	Yes, by chemical methods.
Examples	O_2, Fe, S	H_2O, CO_2, NaCl

★ Both elements and compounds are pure substances because each has a definite composition.

REMEMBER Mixtures are physical combinations. Compounds are chemical combinations.

MATTER AND ITS PROPERTIES

Lesson 3 | How Compounds Can Be Decomposed

Science Field: Materials Science | **Topic:** Chemical Decomposition of Compounds

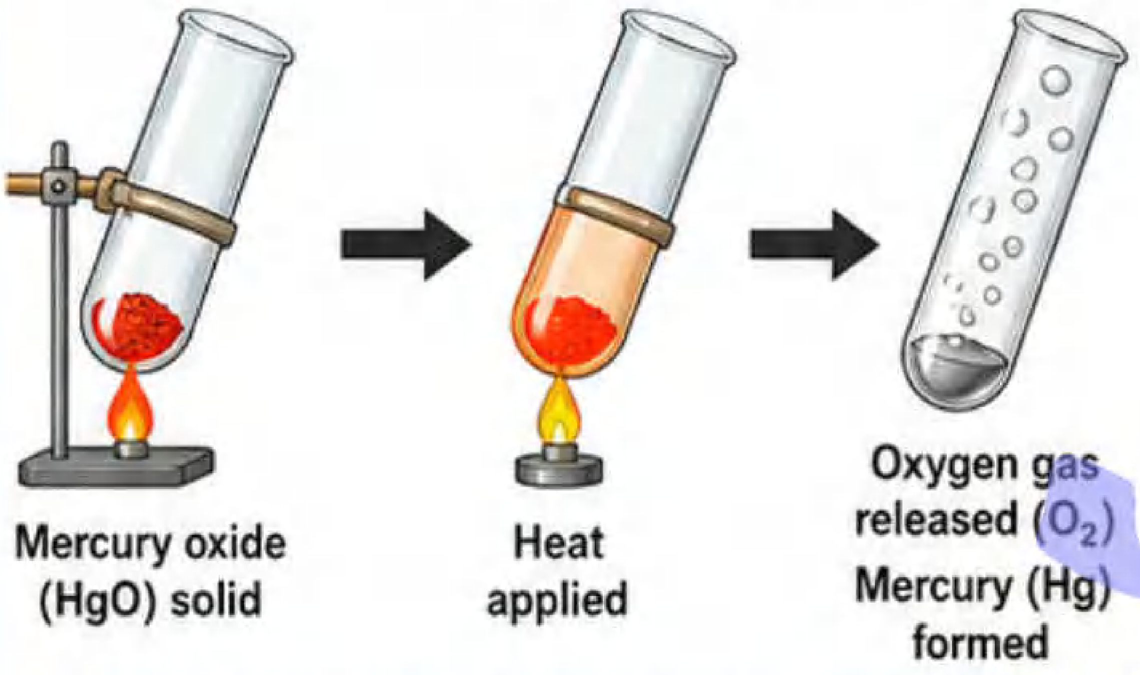
KEY CONCEPT Compounds can be broken down only by chemical methods.

Two Important Methods

1 Thermal Decomposition

Some compounds decompose when heated.

Mercury oxide (HgO) decomposes by heating into mercury (Hg) and oxygen (O_2).



$$2HgO \longrightarrow 2Hg + O_2$$

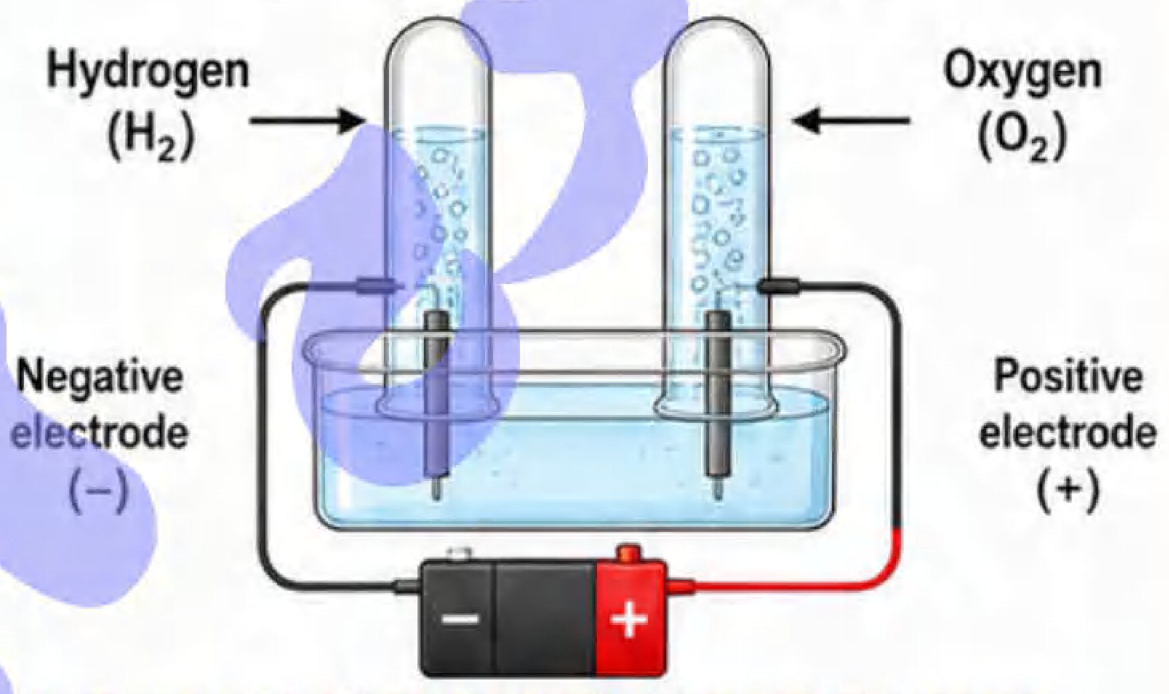
1. Heat mercury oxide.
2. The compound decomposes.
3. Mercury and oxygen are produced.

★ A new set of substances is formed.

2 Electrolysis

Some compounds decompose when an electric current passes through them.

Water (acidified for conductivity) decomposes into hydrogen (H_2) and oxygen (O_2).



$$2H_2O \longrightarrow 2H_2 + O_2$$

1. Electric current passes through the water.
2. Hydrogen forms at the negative electrode.
3. Oxygen forms at the positive electrode.
4. The gases are collected separately.

★ Electrolysis is a chemical change.

Why Is This Chemical Separation?

- The original compound changes into new substances.
- The components are not recovered by a simple physical method.
- Chemical bonds are broken.

Important Difference

Physical separation	→ mixture, no new substance.
Chemical decomposition	→ compound, new substances form.

Remember

Mixtures are separated physically, but compounds are decomposed chemically.

MATTER AND ITS PROPERTIES

Lesson 3 | Molecules and Chemical Formulae

Science Field: Materials Science

Topic: Molecules of Elements and Compounds

KEY CONCEPT A chemical formula shows the kinds of atoms and the number of each atom in a molecule or compound.

1 | Molecules of Elements

Carbon (C)

one atom only

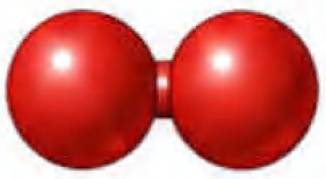
Monatomic

Mercury (Hg)

one atom only

Monatomic

Oxygen (O_2)



two oxygen atoms

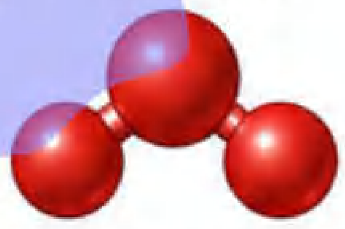
Diatomic

Hydrogen (H_2)

two hydrogen atoms

Diatomic

Ozone (O_3)



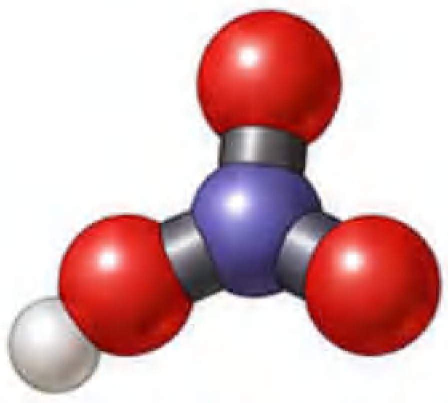
three oxygen atoms

Triatomic

Molecules of elements contain atoms of the same element.

2 | Molecules of Compounds

Nitric Acid (HNO_3)



Formula Decoder

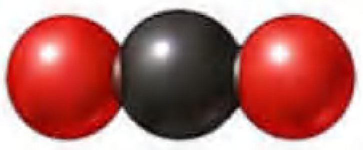
H = hydrogen → 1 atom
N = nitrogen → 1 atom
O_3 = oxygen → 3 atoms

Total number of atoms in one HNO_3 molecule = **5 atoms**

Water (H_2O)

Hydrogen = 2 atoms
Oxygen = 1 atom
Total = **3 atoms**

Carbon Dioxide (CO_2)



Carbon = 1 atom
Oxygen = 2 atoms
Total = **3 atoms**

Molecules of compounds contain atoms of different elements.

3 | Reading a Chemical Formula

① Na — Read the element symbols.

② H_2O — Read the subscript numbers.

③ CO_2 — If there is no subscript, the number is 1.

④ Add the atom counts if you need the total number of atoms.

O_2 vs O_3

- Both are made of oxygen atoms.
- O_2 has 2 oxygen atoms.
- O_3 has 3 oxygen atoms.

Different numbers of atoms can make different molecules of the same element.

Remember

A formula tells us what the substance is made of and how many atoms of each element are present.

MATTER AND ITS PROPERTIES

Lesson 3 | Organic and Inorganic Compounds

Science Field: Materials Science | **Topic:** Classification of Compounds

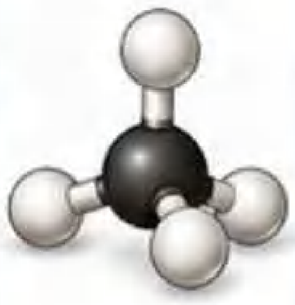
KEY CONCEPT Compounds can be classified into organic compounds and inorganic compounds.

Organic Compounds

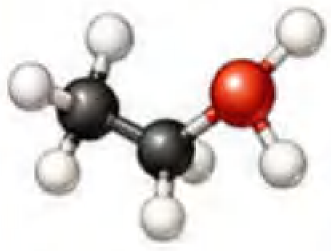
Organic compounds are carbon compounds that usually contain hydrogen bonded with carbon.

Examples

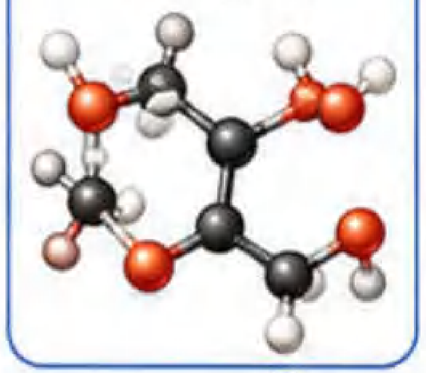
Methane
(CH_4)



Ethanol
(C_2H_5OH)



Glucose
($C_6H_{12}O_6$)



Key Features

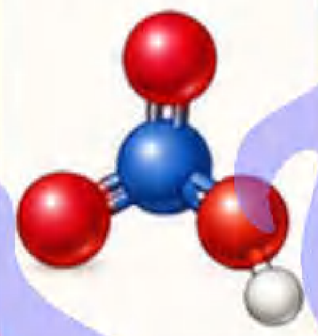
- ✓ Contain carbon.
- ✓ Usually contain carbon–hydrogen bonds.
- ✓ Many are important in living organisms.

Inorganic Compounds

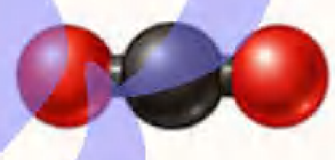
Inorganic compounds are compounds that do not follow the usual carbon-hydrogen pattern of organic compounds.

Examples

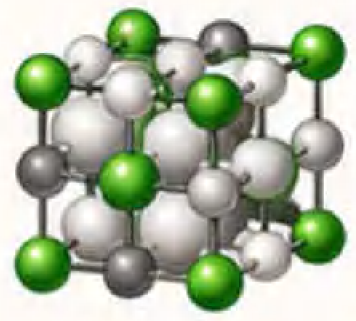
Nitric acid
(HNO_3)



Carbon dioxide
(CO_2)



Sodium chloride
(NaCl)



Key Features

- ✓ May or may not contain carbon.
- ✓ Do not show the usual carbon–hydrogen pattern.
- ✓ Include many acids, salts, oxides, and water-based compounds.

Compare the Two Types

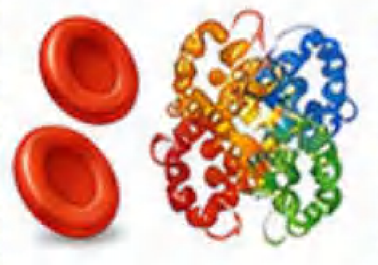
Organic Compounds	Aspect	Inorganic Compounds
Based on carbon compounds.	Main idea	Do not follow the usual carbon-hydrogen pattern.
Carbon (C), Hydrogen (H), often Oxygen (O), Nitrogen (N), Phosphorus (P), Sulfur (S)	Typical atoms present	May include any elements: metals, nonmetals, and metalloids
Methane, ethanol, glucose	Common examples	Nitric acid, carbon dioxide, sodium chloride
Essential for life processes and biological functions.	Biological importance	Support life indirectly (e.g., minerals, water) and used in many non-living applications.

Why Are Organic Compounds Important?

Polymers / plastics

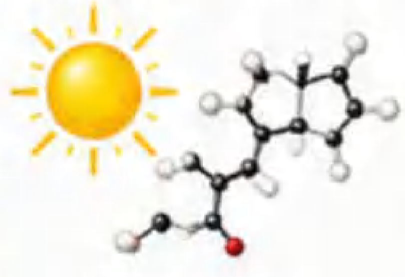
Used in many everyday products.

Hemoglobin in blood



Transports oxygen in the body.

Vitamin D and biological molecules



Support growth, immunity, and health.

CAUTION

Carbon dioxide contains carbon, but it is classified as an inorganic compound.

Remember

Organic compounds are usually based on carbon and hydrogen. Inorganic compounds include many other types of compounds.

MATTER AND ITS PROPERTIES

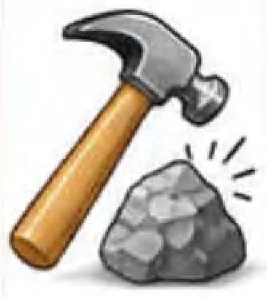
Lesson 3 | Physical Properties of Matter

Science Field: Materials Science | **Topic:** Physical Properties

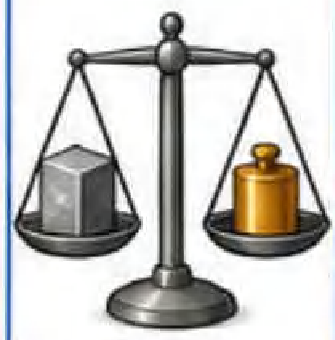
KEY CONCEPT Physical properties can be observed or measured without changing the substance into a new substance.

Examples of Physical Properties

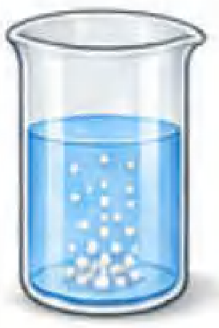
Hardness



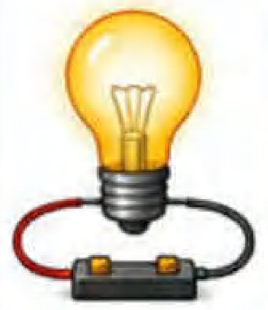
Density



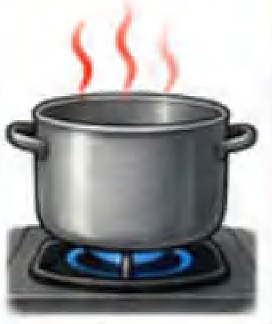
Solubility



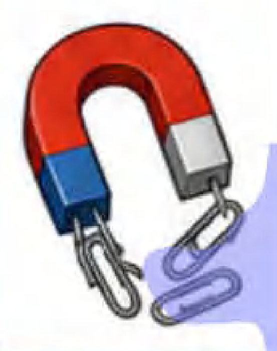
Electrical Conductivity



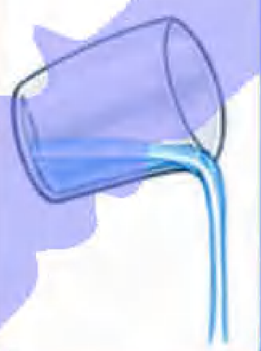
Thermal Conductivity



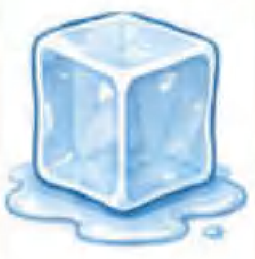
Magnetism



Viscosity

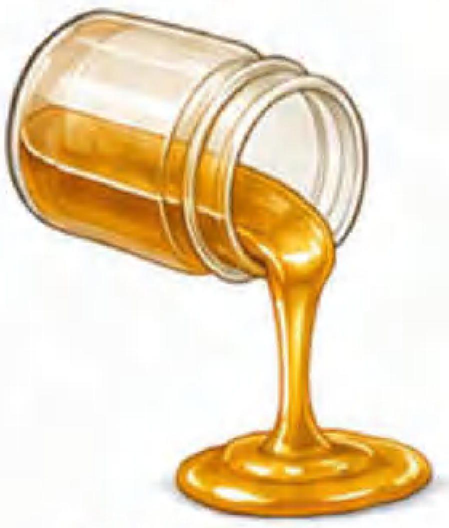


Melting Point



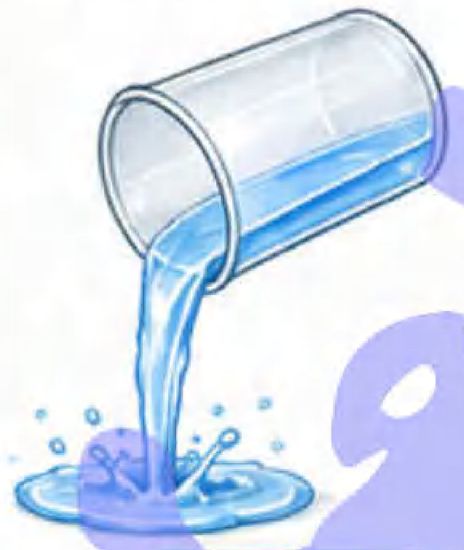
Viscosity

Viscosity is the resistance of a liquid to flow.



Honey

- Honey flows slowly → high viscosity.



Water

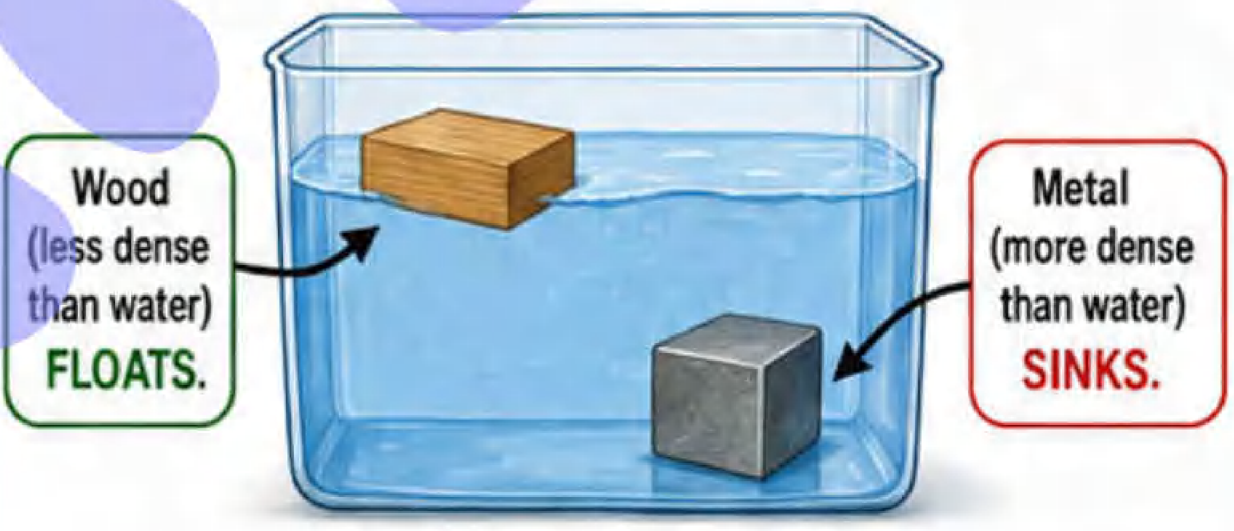
- Water flows quickly → low viscosity.

★ Liquids with greater internal friction have higher viscosity.

Application
Viscosity affects how liquids move and are used.

Density

Density tells us how much mass is found in a certain volume.



- A substance less dense than water **floats.**
- A substance more dense than water **sinks.**

★ Density helps explain floating and sinking.

High density =
more mass in the same volume.

Why Are Physical Properties Useful?

They help us identify substances.

They help us compare materials.

They help us choose suitable materials for use.

They can be measured without causing a chemical change.

★ Remember

✓ When a physical property is observed, the substance remains the same substance.

Lesson 3 | Melting Point and Useful Physical Properties

Science Field: Materials Science

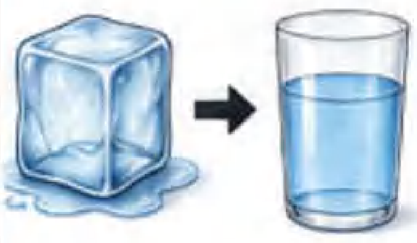
Topic: Melting Point and Applications

KEY CONCEPT A physical property helps us understand and use a material without changing its chemical identity.

1 Melting Point

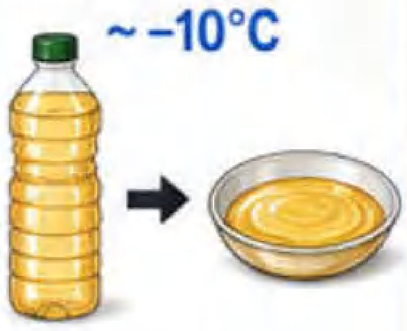
Melting point is the temperature at which a solid changes into a liquid.

Ice
0°C



Ice melts into water.

Cooking Oil
~ −10°C



Oil melts at low temperature.

Metal Pan (Iron)
~1538°C

Iron melts at a very high temperature.

- ★ Different substances have different melting points.
- ★ A low melting point means a substance melts easily.
- ★ A high melting point means a substance stays solid at higher temperatures.

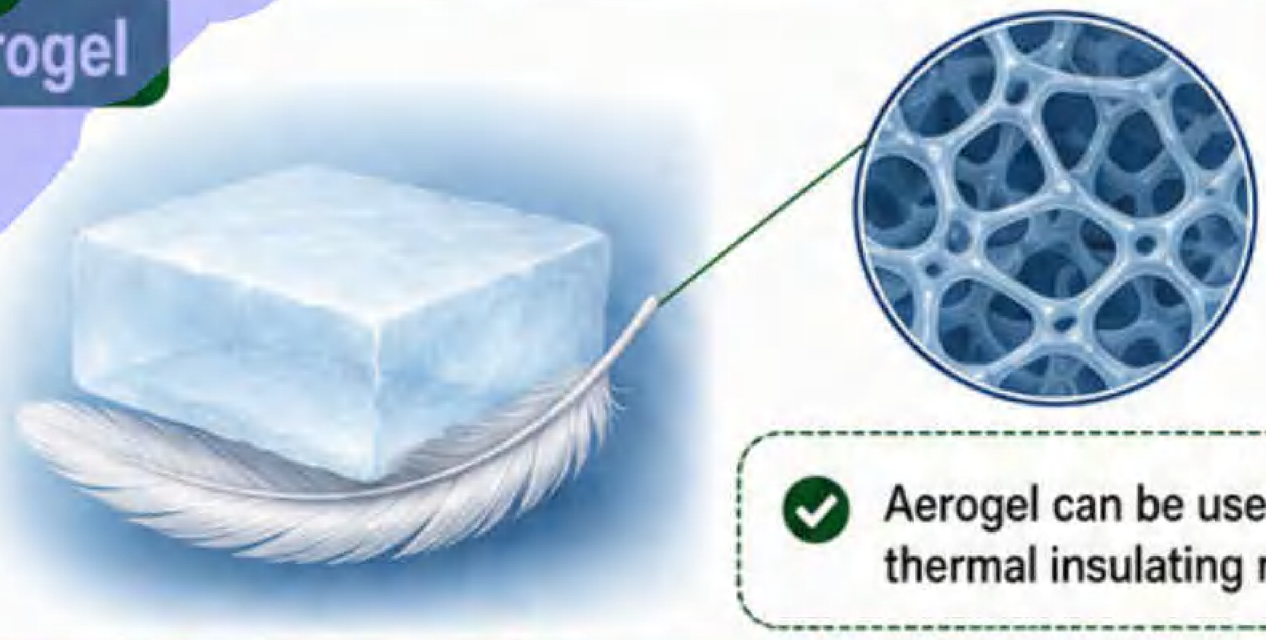
2 Why Does Melting Point Matter?

- It helps identify substances.
- It helps compare materials.
- It helps choose materials for heating or cooling conditions.
- It is important in manufacturing and daily life.

3 Technological Application: Aerogel

Aerogel is an extremely light solid material that contains about 99.8% air.

- ✓ Very low density.
- ✓ Excellent heat insulator.
- ✓ Can withstand high temperatures.
- ✓ Very useful in advanced technology.



✓ Aerogel can be used as a thermal insulating material.

Real-Life Examples

Ice cube
Melts at 0°C.

Cooking pan
Used at high temperatures.

Insulating material
Reduces heat transfer.

Heating situation
Materials must withstand high temperatures.

Remember Physical properties such as melting point and density help us choose the right material for the right job.

Lesson 3 | Chemical Properties of Matter

Science Field: Materials Science | **Topic:** Chemical Properties

KEY CONCEPT Chemical properties appear when a substance changes into one or more new substances.

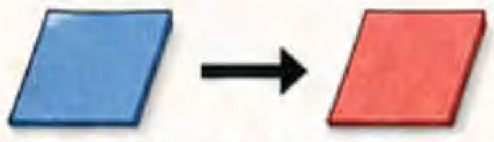
Examples of Chemical Properties

- Reaction with indicators
- Formation of a precipitate
- Flammability
- Reactivity with other substances

1 Effect on Litmus Paper

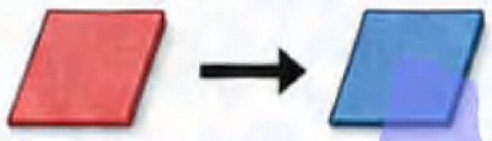
Some substances can be identified by how they change litmus paper.

Acidic substance: turns blue litmus paper red.

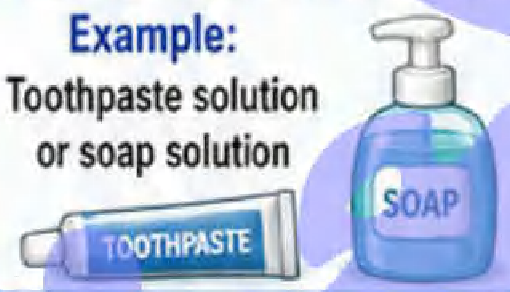


Example: Lemon juice or orange juice

Basic substance: turns red litmus paper blue.



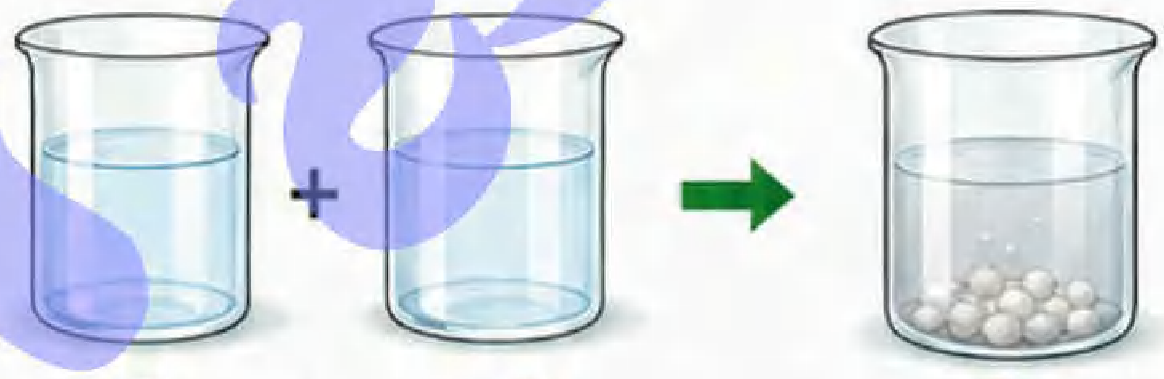
Example: Toothpaste solution or soap solution



The color change gives evidence about the chemical nature of the substance.

2 Formation of a Precipitate

When two solutions react, an insoluble solid may form. This solid is called a precipitate.



1. Start with two solutions.
2. Mix them.
3. A new solid appears.

The precipitate is evidence of a chemical reaction.

Physical Property or Chemical Property?

Physical property observed without forming a new substance.

Chemical property observed when a new substance forms.

Why Are Chemical Properties Important?

- They help identify substances.
- They help predict chemical behavior.
- They show how substances react in real life.

Remember A chemical property is revealed during a chemical change.

MATTER AND ITS PROPERTIES

Lesson 3 | Uses of Materials and Final Review

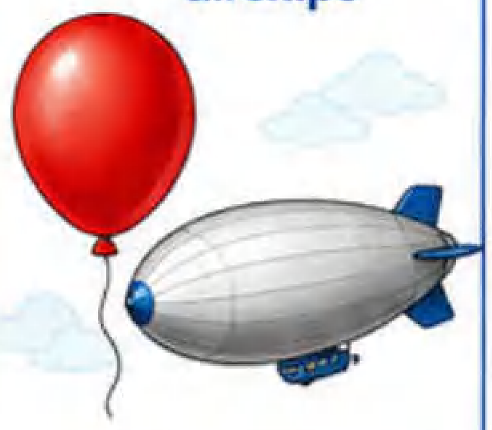
Science Field: Materials Science

Topic: Uses of Materials According to Their Properties

KEY CONCEPT Materials are chosen for use according to their physical and chemical properties.

1. Using Materials According to Their Properties

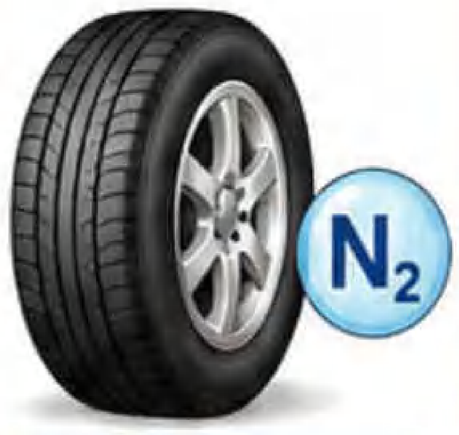
1 Helium in balloons and airships



Property
Low density

Use
Helps lifting.

2 Nitrogen in car tires



Property
Stable and less reactive

Use
Suitable for inflation and safety.

3 Stainless steel in cooking utensils

Property
Strong and resists rust

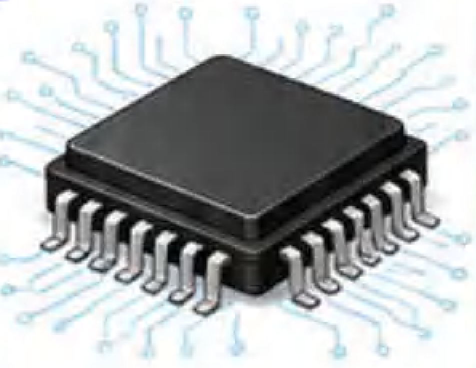
Use
Suitable for pots and kitchen tools.

4 Aluminum alloy in aircraft

Property
Light and strong

Use
Suitable for airplane bodies.

5 Silicon in electronic chips



Property
Useful in electronics (semiconducting behavior)

Use
Used in devices and circuits.

2. Lesson Review: What We Learned

1 Classification of materials

Materials are classified into mixtures and pure substances.

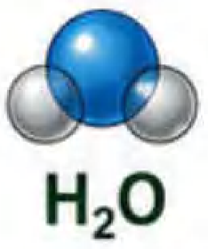
2 Separation of mixtures

Mixtures can be separated into their components using physical methods.

3 Pure substances

Pure substances are classified into elements and compounds.

4 Molecules and formulae



Molecules and formulae show symbols and the number of atoms.

5 Physical and chemical properties

Properties describe how materials behave and change.

6 Properties and uses

Materials are chosen for the right material for the right job.

Big Idea
Understanding composition and properties helps us identify, compare, and use materials correctly.

Remember
Science helps us choose materials by connecting structure, properties, and uses.

Science Theater

CHEMICAL BONDS

1/10

Lesson 4 | Valence Electrons, Valency and Stability

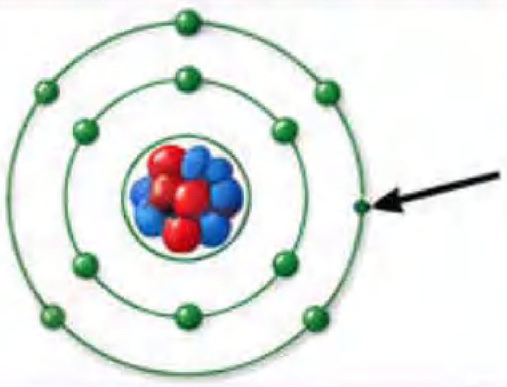
Science Field: Materials Science

Topic: Valence Electrons and Stability

KEY CONCEPT The number of valence electrons determines valency and helps explain the chemical stability of elements.

1. Valence Electrons and Stability

Valence electrons are the electrons present in the **outermost energy level** (shell) of an atom.



Example: Sodium (Na)

Electron configuration: 2, 8, 1

Valence electrons: 1 (outermost shell)

2. Connecting Valence Electrons to Valency for Representative Elements

A. METALS

(1, 2, or 3 valence electrons)

Metals tend to lose valence electrons to achieve stability.

Element	Outer-Shell Electrons	Valence (Valency)	Lewis Dot Structure
Na (Sodium)	1	1	$\mathrm{Na}\cdot$
Mg (Magnesium)	2	2	$\cdot\mathrm{Mg}\cdot$
Al (Aluminum)	3	3	$\cdot\overset{\cdot}{\underset{\cdot}{\mathrm{Al}}}\cdot$

Metals usually have 1–3 valence electrons and form positive ions by losing them.

B. NONMETALS

(5, 6, or 7 valence electrons)

Nonmetals tend to gain electrons to achieve stability.

Element	Outer-Shell Electrons	Valence (Valency)	Lewis Dot Structure
N (Nitrogen)	5	3	$\cdot\overset{\cdot}{\underset{\cdot}{\mathrm{N}}}\cdot$
O (Oxygen)	6	2	$\cdot\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{O}}}\colon$
F / Cl (Fluorine / Chlorine)	7	1	$\colon\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{F}}}\cdot$

Nonmetals usually have 5–7 valence electrons and gain electrons to form negative ions.

C. NOBLE GASES

(Complete outer shells)

Noble gases are chemically stable because their outermost energy level is complete.

Element	Electron Configuration	Valence (Valency)	Lewis Dot Structure
He (Helium)	2 (1st shell)	0	$\mathrm{He}\colon$
Ne (Neon)	2, 8 (octet)	0	$\colon\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{Ne}}}\colon$
Ar (Argon)	2, 8, 8 (octet)	0	$\colon\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{Ar}}}\colon$

Helium is a special case with 2 electrons in the first shell (duet). Ne and Ar have complete octets, making them stable.

3. Lewis-Dot Structures (Selected Examples)

Na	Mg	Al	N	O	F	Ne	Ar	He
$\mathrm{Na}\cdot$	$\cdot\mathrm{Mg}\cdot$	$\cdot\overset{\cdot}{\underset{\cdot}{\mathrm{Al}}}\cdot$	$\cdot\overset{\cdot}{\underset{\cdot}{\mathrm{N}}}\cdot\cdot$	$\cdot\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{O}}}\colon$	$\colon\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{F}}}\colon$	$\colon\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{Ne}}}\cdot$	$\colon\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathrm{Ar}}}\colon$	$\mathrm{He}\colon$

4. How valency is estimated

Outer-Shell Electrons	How Valency is Estimated
1, 2, 3	Valency usually equals the same number. (Atoms tend to lose these electrons.)
5, 6, 7	Valency usually equals 8 minus that number. (Atoms tend to gain electrons to complete octet.)
8 (or 2 for He)	Valency is zero. (Outer shell is complete; atoms are stable.)

Remember

- Valence electrons are in the outermost energy level.
- Valency is related to the number of electrons lost, gained, or shared.
- Noble gases are stable because their outer shells are complete.

CHEMICAL BONDS

Lesson 4 | Formation of Ions

Science Field: Materials Science

Topic: Positive and Negative Ions

KEY CONCEPT

Atoms may lose or gain valence electrons to achieve a stable outer energy level and become ions.

1. Formation of Ions

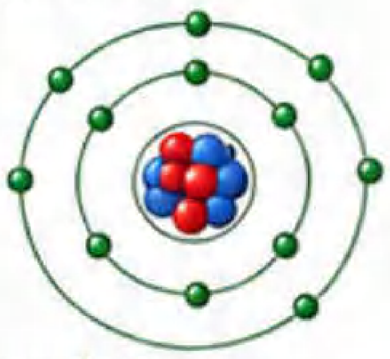
A **cation** is a positive ion formed when a metal atom loses electrons.
An **anion** is a negative ion formed when a nonmetal atom gains electrons.

A. Positive Ion (Cation)

Example: Sodium (Na)

① **Neutral sodium atom**
Electron configuration: 2, 8, 1

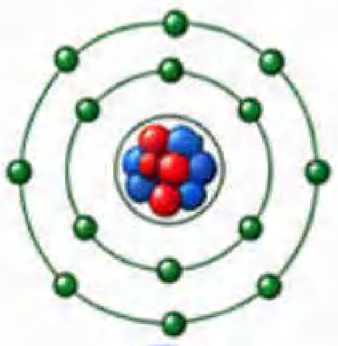
Na



② Loses 1 valence electron → Loss of 1 e^-

③ Forms sodium ion (Na^+)
Electron configuration: 2, 8

Na^+



Protons (remain)	Electrons (change)	Charge (result)
11	11 → 10	+

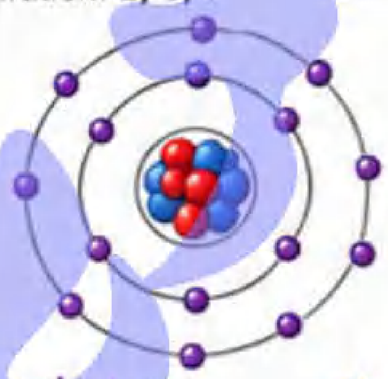
Protons remain 11. Electrons decrease from 11 to 10.
The ion has a **+1 charge.**

B. Negative Ion (Anion)

Example: Chlorine (Cl)

① **Neutral chlorine atom**
Electron configuration: 2, 8, 7

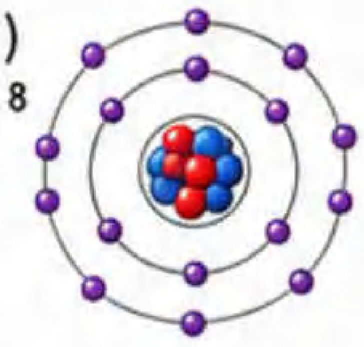
Cl



② Gains 1 valence electron ← Gain of 1 e^-

③ Forms chloride ion (Cl^-)
Electron configuration: 2, 8, 8

Cl^-



Protons (remain)	Electrons (change)	Charge (result)
17	17 → 18	−

Protons remain 17. Electrons increase from 17 to 18.
The ion has a **−1 charge.**

2. Atom vs Ion

Atom	Ion
Neutral	**Charged**
Number of protons equals number of electrons.	Number of protons **does not** equal number of electrons.

3. Cation vs Anion

	Cation (Positive Ion)	Anion (Negative Ion)
Electron change	Loses electrons	Gains electrons
Charge	Positive (+)	Negative (−)
Typical element type	Metal	Nonmetal

4. Common Ions (Examples)

Na^+	Mg^{2+}	Al^{3+}
Sodium ion	Magnesium ion	Aluminum ion
Cl^-	O^{2-}	N^{3-}
Chloride ion	Oxide ion	Nitride ion

Remember

- Ions form when atoms lose or gain electrons.
- A **cation** is positive because it has fewer electrons than protons.
- An **anion** is negative because it has more electrons than protons.

CHEMICAL BONDS

Lesson 4 | The Ionic Bond

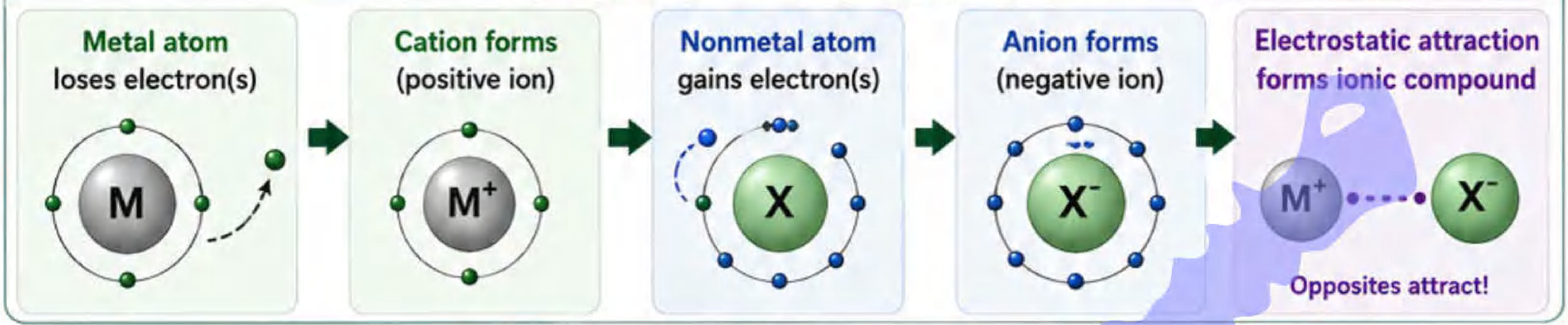
Science Field: Materials Science

Topic: Ionic Bond Formation

KEY CONCEPT

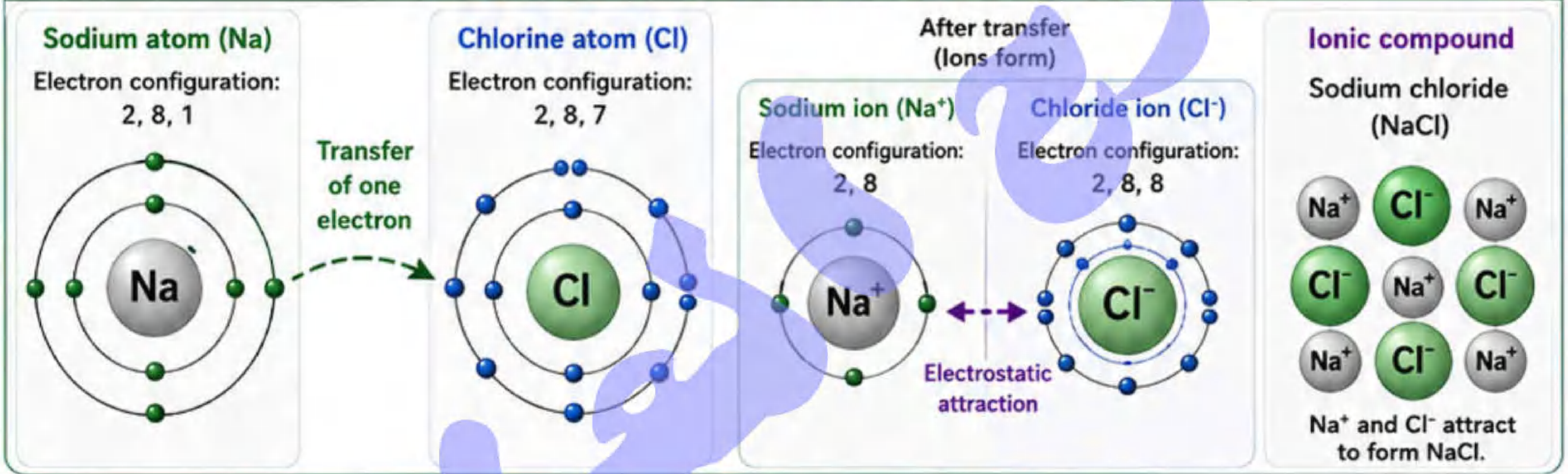
An ionic bond forms when electrons are transferred from one atom to another and oppositely charged ions attract each other.

1. How an Ionic Bond Forms



Metal atom loses electron(s) → **Cation forms** (positive ion) → **Nonmetal atom** gains electron(s) → **Anion forms** (negative ion) → **Electrostatic attraction forms ionic compound**

2. Worked Example: Sodium Chloride (NaCl)



Sodium atom (Na)
Electron configuration:
2, 8, 1

Transfer of one electron

Chlorine atom (Cl)
Electron configuration:
2, 8, 7

After transfer
(Ions form)

Sodium ion (Na^+)
Electron configuration:
2, 8

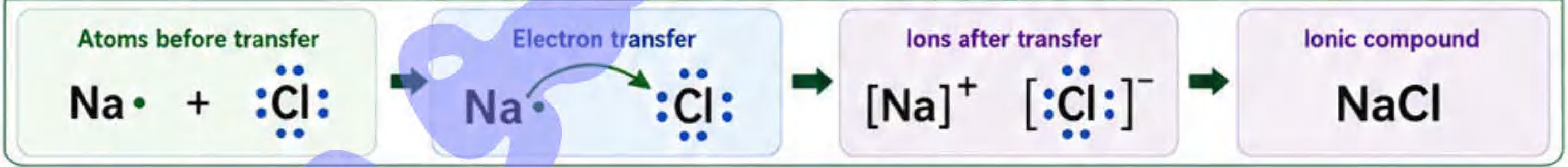
Chloride ion (Cl^-)
Electron configuration:
2, 8, 8

Electrostatic attraction

Ionic compound
Sodium chloride
(NaCl)

Na^+ and Cl^- attract to form NaCl.

3. Lewis-Dot Representation (Same Process)

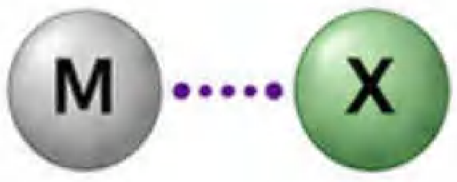


Atoms before transfer: Na• + :Cl: → **Electron transfer**: Na• :Cl: → **Ions after transfer**: $[Na]^+$ $[:Cl:]^-$ → **Ionic compound**: NaCl

4. Definition of Ionic Bond

The ionic bond is the electrostatic attraction between a positive ion and a negative ion.

5. When does it happen?



It usually forms between a metal atom and a nonmetal atom.

6. Ionic bonding steps

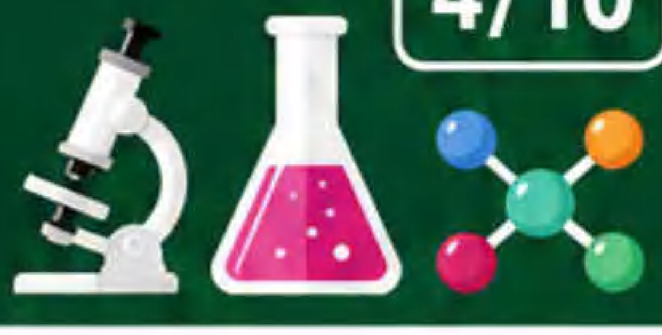
1. **Lose:** The metal atom loses electron(s).
2. **Gain:** The nonmetal atom gains electron(s).
3. **Attract:** Oppositely charged ions attract.
4. **Form compound:** The ions combine to form an ionic compound.

7. Important Idea

- Electrons are transferred, not shared.
- New ions are formed before the compound is formed.
- The ions attract because their charges are opposite.

CHEMICAL BONDS

Lesson 4 | Writing Formulae of Ionic Compounds



Science Field: Materials Science

Topic: Formulae of Ionic Compounds

KEY CONCEPT The formula of an ionic compound shows the simplest whole-number ratio of positive and negative ions so that the total charge is zero.

1. How to Write the Formula of an Ionic Compound

RULE: The total **positive** charge from the cations must equal the total **negative** charge from the anions.

① Example 1: Potassium chloride

Step 1: Write the ions and their charges.

K^+ Potassium (cation) Cl^- Chloride (anion)

Step 2: Balance charges.

K^+ Cl^-

+1 −1

Step 3: Simplest ratio.

1 : 1 → already simplest

Step 4: Write the formula.

$\boxed{KCl}$

Charges balance: +1 + (−1) = 0 ✓

② Example 2: Magnesium oxide

Step 1: Write the ions and their charges.

Mg^{2+} Magnesium (cation) O^{2-} Oxide (anion)

Step 2: Balance charges.

Mg^{2+} O^{2-}

+2 −2

Step 3: Simplest ratio.

1 : 1 → already simplest

Step 4: Write the formula.

$\boxed{MgO}$

Charges balance: +2 + (−2) = 0 ✓

③ Example 3: Aluminum oxide

Step 1: Write the ions and their charges.

Al^{3+} Aluminum (cation) O^{2-} Oxide (anion)

Step 2: Balance charges.

Al^{3+} ×2 O^{2-} ×3

+3 × 2 = +6 −2 × 3 = −6

Step 3: Simplest ratio.

2 : 3 → simplest

Step 4: Write the formula.

$\boxed{Al_2O_3}$

Charges balance: +6 + (−6) = 0 ✓

Note: In ionic formulae, the **cation** is written first and the **anion** second.

2. Charge Balance

Ions	Total Positive Charge	Total Negative Charge	Final Formula
K^+ and Cl^-	+1	−1	KCl
Mg^{2+} and O^{2-}	+2	−2	MgO
Al^{3+} and O^{2-}	+6	−6	Al_2O_3

3. Quick Practice Pattern

① KCl

K^+ (+1) Cl^- (−1)

1 : 1 → KCl

② MgO

Mg^{2+} (+2) O^{2-} (−2)

1 : 1 → MgO

③ Al_2O_3

Al^{3+} (+3) ×2 O^{2-} (−2) ×3

2 : 3 → Al_2O_3

Remember

- The total charge of an ionic compound is zero.
- Use the simplest whole-number ratio of ions.
- Write the positive ion first.

CHEMICAL BONDS

Lesson 4 | Ionic Compounds and Their Properties

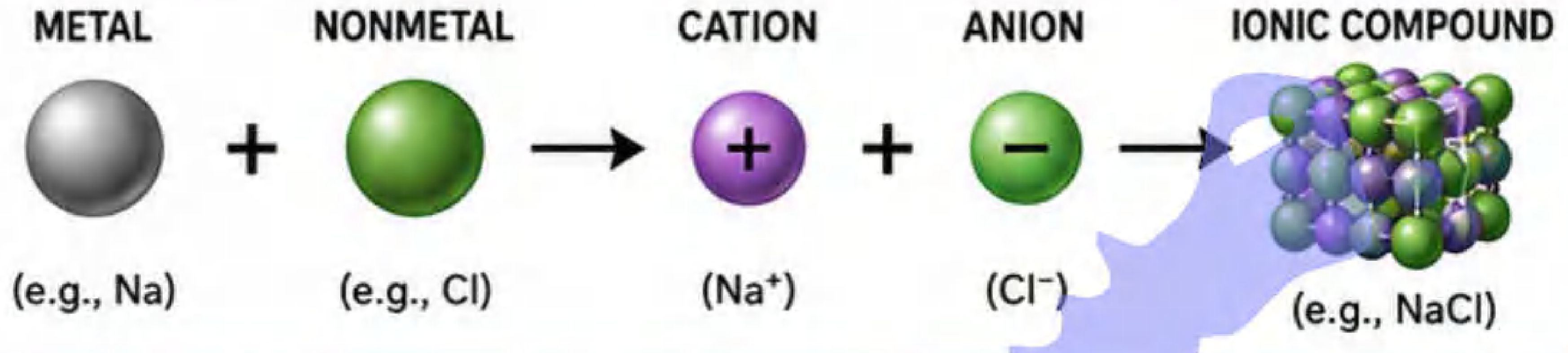
Science Field: Materials Science

Topic: Properties of Ionic Compounds

KEY CONCEPT Ionic compounds form between metals and nonmetals and have characteristic physical properties.

1. What Are Ionic Compounds?

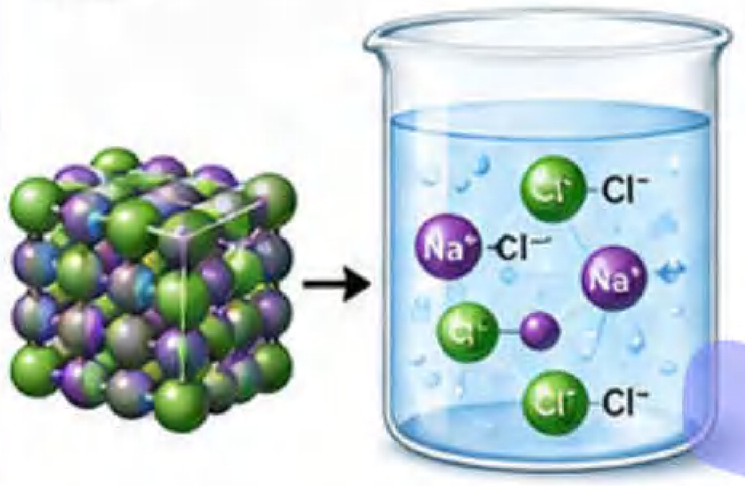
An **ionic compound** is a compound made of positive and negative ions held together by ionic bonds.



2. Properties of Ionic Compounds

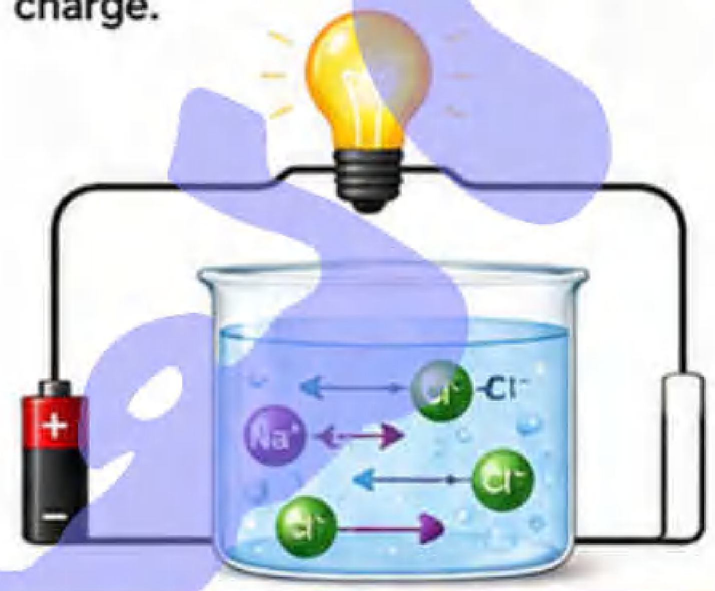
MOST DISSOLVE IN WATER

Ionic compound often break apart into ions when placed in water.



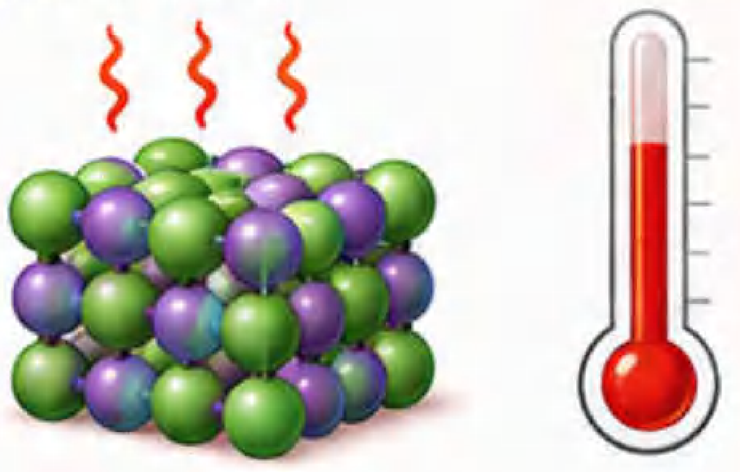
THEIR AQUEOUS SOLUTIONS AND MOLTEN FORMS CONDUCT ELECTRICITY

Ions are free to move and carry charge.



THEY HAVE HIGH MELTING AND BOILING POINTS

A lot of energy is needed to overcome the strong attractions between ions.



NORMALLY SOLID AT ROOM TEMPERATURE

Ionic compounds are usually crystalline solids under normal conditions.

EXAMPLE: SODIUM CHLORIDE (NaCl)

1. Na (metal) loses 1 electron → Na^+
2. Cl (nonmetal) gains 1 electron → Cl^-
3. Na^+ and Cl^- attract each other to form the ionic compound NaCl.

3. Why do these properties appear?

1. Strong attraction between oppositely charged ions

Ionic bonds are electrostatic attractions, which are strong and require a lot of energy to break.

2. Presence of ions in solution or molten state

When dissolved in water or melted, ions are free to move and carry electric charge.

3. Lattice arrangement of ions

Ions are arranged in a regular 3D lattice, holding the structure together and giving ionic compounds their solid form.

Remember

- Ionic compounds usually form between metals and nonmetals.
- They are often solids.
- Many dissolve in water.
- They conduct electricity when molten or dissolved in water.

CHEMICAL BONDS

Lesson 4 | The Covalent Bond

Science Field: Materials Science

Topic: Covalent Bonding

KEY CONCEPT A covalent bond forms when atoms share electrons instead of transferring them.

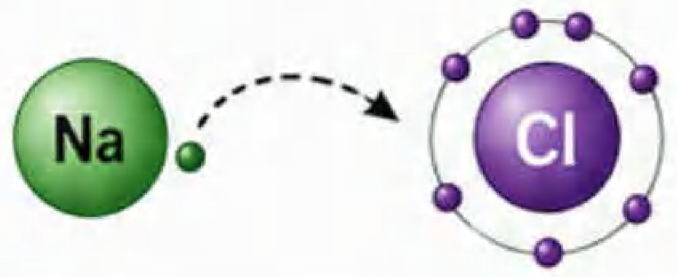
1. How Covalent Bonds Form

Covalent bonding usually occurs between **nonmetal** atoms. The atoms share electrons to achieve a stable outer-shell arrangement.

Ionic vs Covalent Bonding

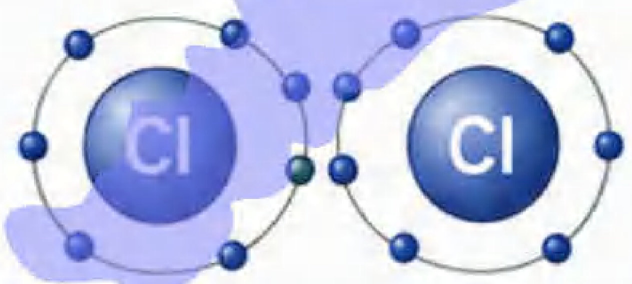
IONIC BONDING

Transfer of electrons.

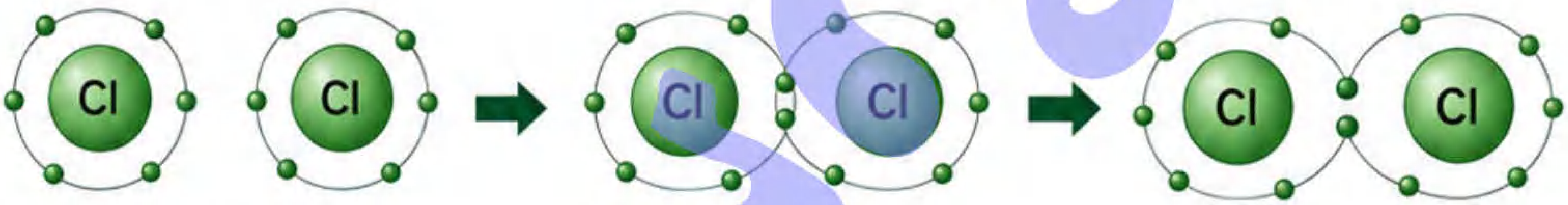


COVALENT BONDING

Sharing of electrons.



2. Formation of a Covalent Bond (Example: Chlorine, Cl_2)



1. Atoms approach

Each chlorine atom has 7 valence electrons.

2. Electrons are shared

Each atom contributes one electron to form a shared pair.

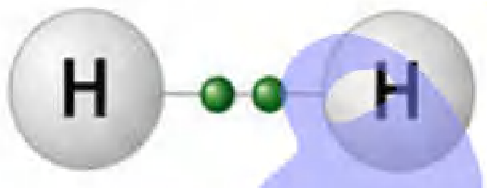
3. Covalent bond forms

A shared pair holds the atoms together as Cl_2.

3. Types of Covalent Bonds

SINGLE COVALENT BOND

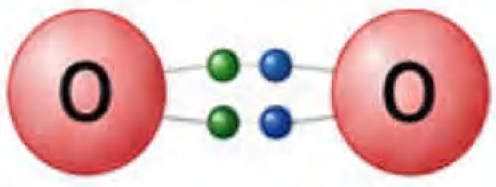
One shared pair of electrons.



Example: H–H

DOUBLE COVALENT BOND

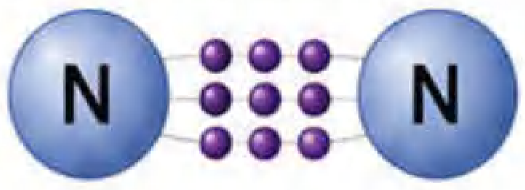
Two shared pairs of electrons.



Example: O=O

TRIPLE COVALENT BOND

Three shared pairs of electrons.



Example: N≡N

DEFINITION A covalent bond is a bond formed by the sharing of one or more pairs of electrons between two atoms.

WHY IT HAPPENS Sharing electrons helps each atom reach a more stable outer-shell arrangement.

Remember

- Electrons are shared, not transferred.
- Covalent bonds usually form between nonmetals.
- A shared pair forms a bond.
- There may be one, two, or three shared pairs.

CHEMICAL BONDS

Lesson 4 | Single Covalent Bonds

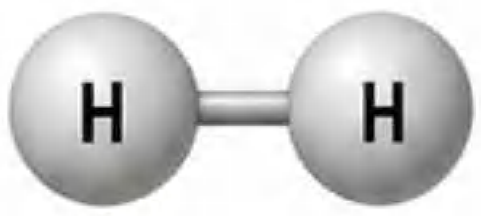
Science Field: Materials Science

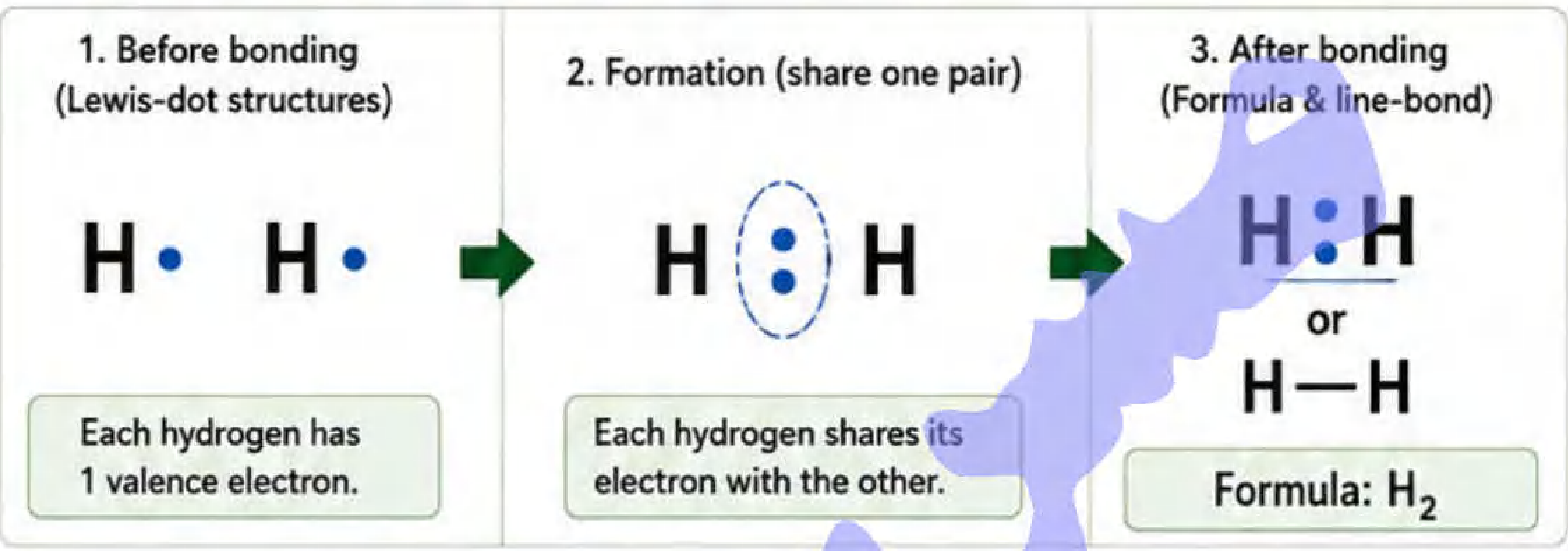
Topic: Single Covalent Bonds

KEY CONCEPT A single covalent bond is formed when two atoms share one pair of electrons.

1. Examples of Single Covalent Bonds

A Hydrogen molecule (H_2)



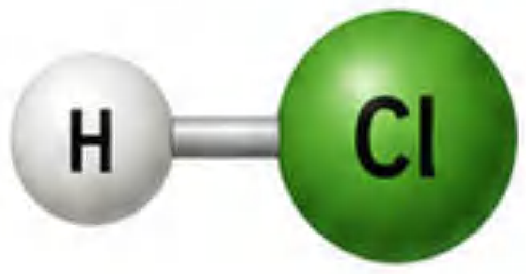

1. Before bonding (Lewis-dot structures)
H• H•
2. Formation (share one pair)
H : H
3. After bonding (Formula & line-bond)
H:H
or
H—H

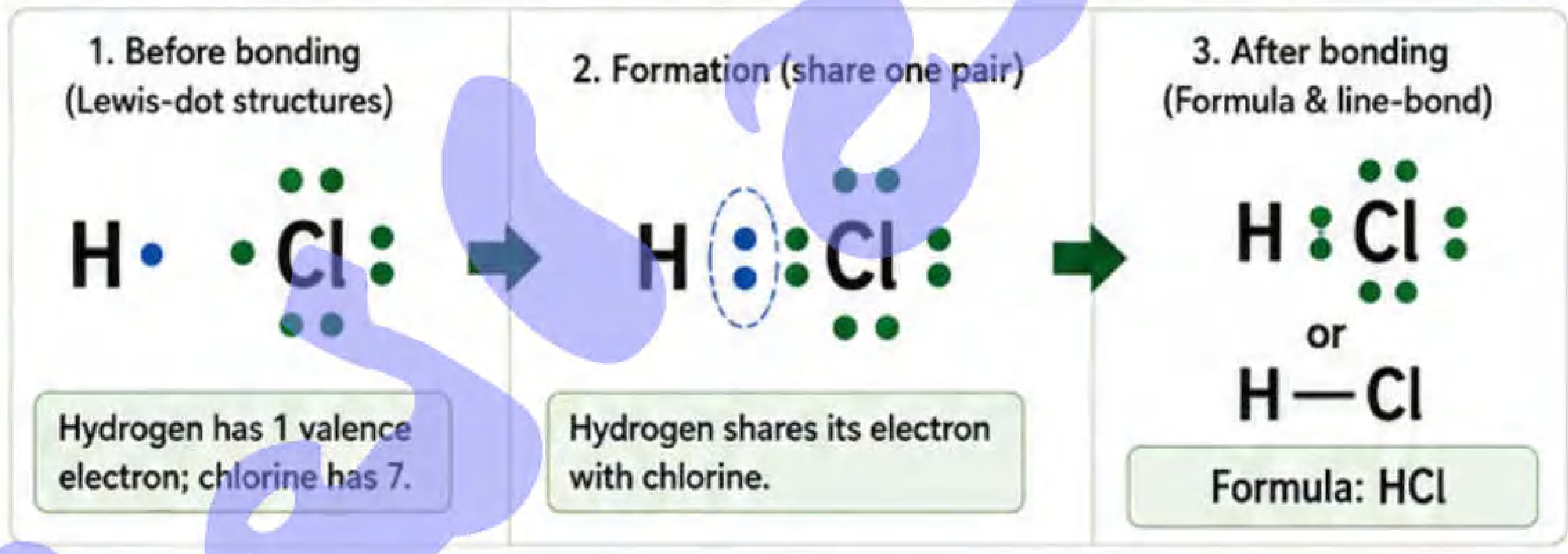
Each hydrogen has 1 valence electron.

Each hydrogen shares its electron with the other.

Formula: H_2

B Hydrogen chloride (HCl)



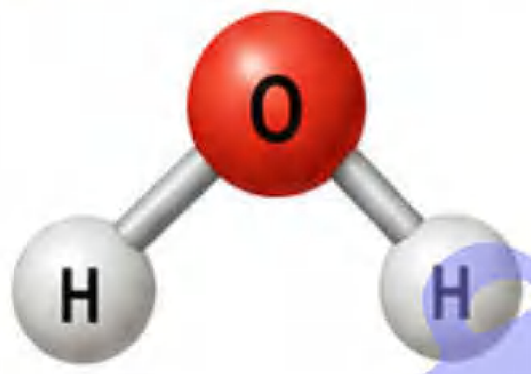

1. Before bonding (Lewis-dot structures)
H• •Cl
2. Formation (share one pair)
H : Cl
3. After bonding (Formula & line-bond)
H : Cl
or
H—Cl

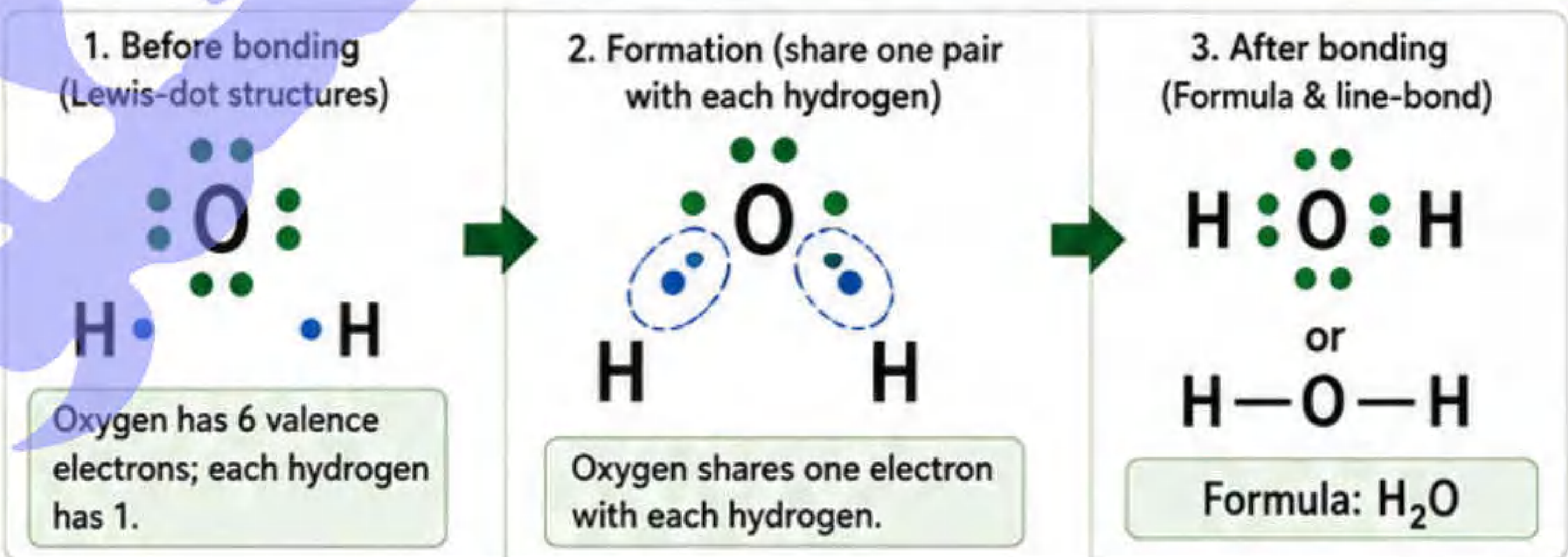
Hydrogen has 1 valence electron; chlorine has 7.

Hydrogen shares its electron with chlorine.

Formula: HCl

C Water molecule (H_2O)




1. Before bonding (Lewis-dot structures)
O
H• •H
2. Formation (share one pair with each hydrogen)
O
H H
3. After bonding (Formula & line-bond)
H : O : H
or
H—O—H

Oxygen has 6 valence electrons; each hydrogen has 1.

Oxygen shares one electron with each hydrogen.

Formula: H_2O

What is shared?

One pair of electrons is shared in each single covalent bond.

Why are these molecules stable?

Each hydrogen reaches a duet (2 electrons). Atoms such as chlorine or oxygen move toward complete outer shells through sharing.

Remember

- A single covalent bond = one shared pair.
- H_2, HCl, and H_2O are examples.
- Lewis-dot structures help show shared electrons.

CHEMICAL BONDS

Lesson 4 | Double and Triple Covalent Bonds

Science Field: Materials Science

Topic: Multiple Covalent Bonds

KEY CONCEPT

Double and triple covalent bonds form when atoms share two or three pairs of electrons.

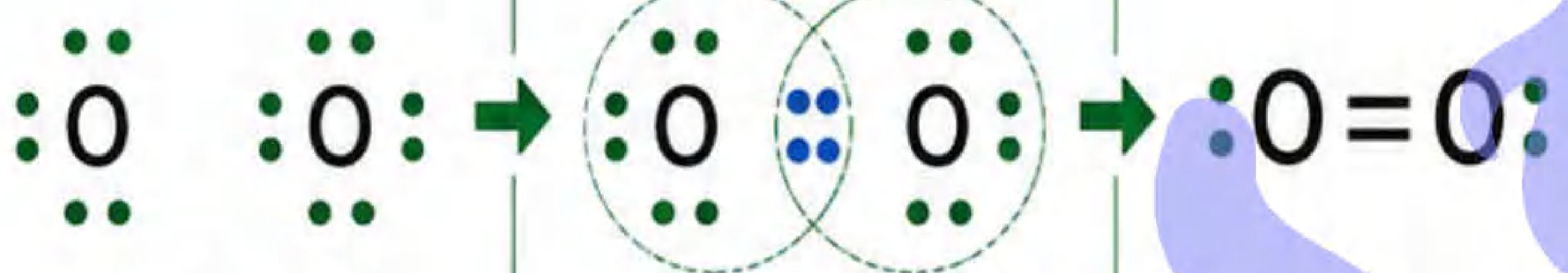
1. Multiple Covalent Bonds

A. DOUBLE COVALENT BOND IN OXYGEN MOLECULE (O_2)

① Two oxygen atoms (each has 6 valence electrons)

② Formation of two shared pairs

③ Final Lewis-dot structure



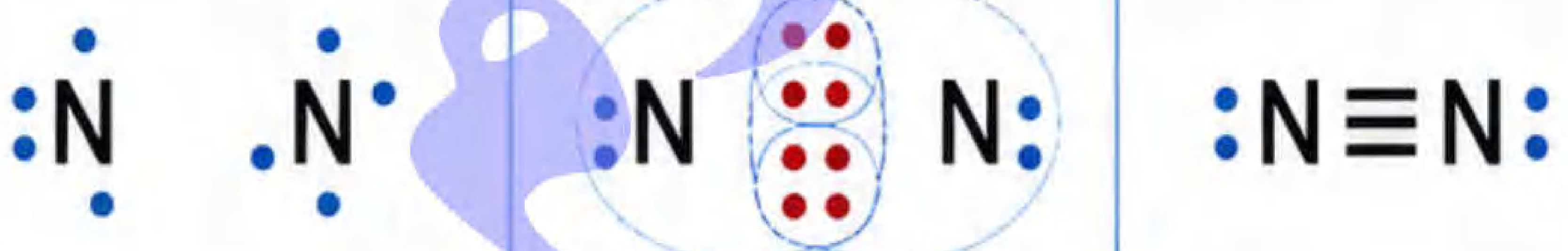
A double bond contains **two shared pairs** of electrons.

B. TRIPLE COVALENT BOND IN NITROGEN MOLECULE (N_2)

① Two nitrogen atoms (each has 5 valence electrons)

② Formation of three shared pairs

③ Final Lewis-dot structure



A triple bond contains **three shared pairs** of electrons.

Comparison of Covalent Bonds

Bond Type	Number of Shared Pairs	Example	Bond Symbol
Single Bond	1	H_2	H–H
Double Bond	2	O_2	O=O
Triple Bond	3	N_2	N≡N

Why do multiple bonds form?

Some atoms do not have enough valence electrons to complete their outer shell by sharing just one pair. To achieve a stable noble gas configuration, they share two or three pairs of electrons.

Remember

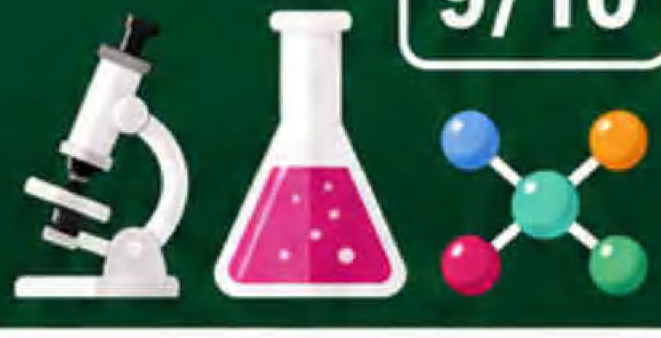
- Double bond = two shared pairs.
- Triple bond = three shared pairs.
- O_2 and N_2 are classic examples.

Science Theater

CHEMICAL BONDS

Lesson 4 | Ionic vs Covalent Compounds

9/10



Science Field: Materials Science

Topic: Comparison of Bond Types and Compounds

KEY CONCEPT

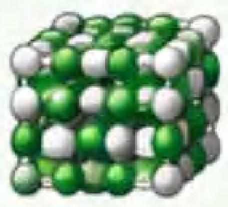
Ionic and covalent compounds differ in how their atoms bond and in many of their physical properties.

1. Comparing Ionic and Covalent Compounds

	Ionic Compounds	Covalent Compounds
How the bond forms	Transfer of electrons	Sharing of electrons
Types of elements involved	Metal + nonmetal	Nonmetal + nonmetal
Type of particles formed	Ions	Molecules
Solubility in water	Often soluble	Many are less soluble or vary
Electrical conductivity	Conduct when molten or in aqueous solution	Usually do not conduct electricity
Melting and boiling points	Usually high	Usually lower
Physical state at room temperature	Often solid	May be gases, liquids, or low-melting solids

2. NaCl vs HCl

NaCl VS **HCl**



NaCl:

- Ionic compound
- Solid
- High melting point
- Dissolves in water
- Aqueous solution conducts electricity

HCl:

- Covalent compound
- Molecular substance
- Lower melting/boiling than ionic salts
- Forms molecules
- Does not behave like an ionic crystal

3. Bond Definitions

Ionic bond

A chemical bond formed by the transfer of electrons from a metal to a nonmetal, creating ions that attract each other.

Covalent bond

A chemical bond formed by the sharing of one or more pairs of electrons between nonmetal atoms.

4. Fast Distinction

transfer	→	ionic
share	→	covalent
ions	→	ionic
molecules	→	covalent
conducts in solution	→	ionic
usually does not conduct	→	covalent

Remember

- Ionic compounds are based on ions.
- Covalent compounds are based on molecules.
- Ionic compounds often conduct in solution.
- Covalent compounds usually do not conduct electricity.

Science Theater

CHEMICAL BONDS

Lesson 4 | The Unique Carbon Atom and Final Review

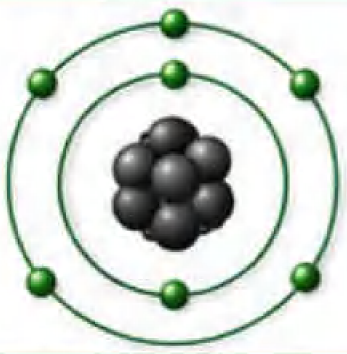
Science Field: Materials Science

Topic: Carbon and Lesson Review

KEY CONCEPT Carbon has four valence electrons and can form many covalent bonds, allowing it to build a huge variety of organic structures.

1. The Unique Carbon Atom

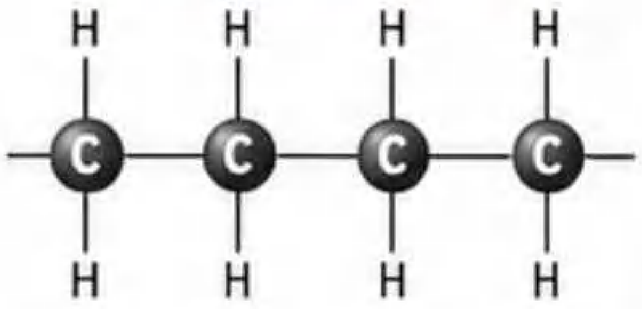
Carbon has 4 valence electrons, so it can form four covalent bonds. It can bond with other carbon atoms and with many other elements.



Carbon (C)
Electron configuration: 2, 4
Valence electrons: 4

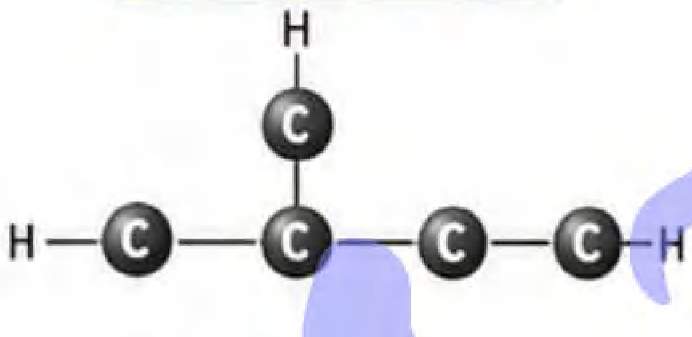
Types of Carbon Skeletons

Straight Chain



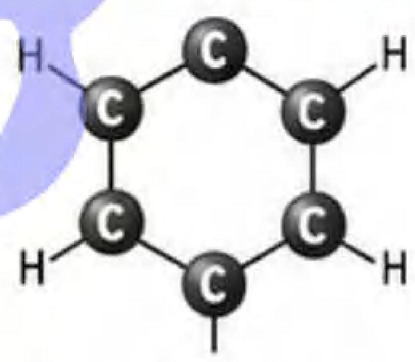
Carbons linked in a line.

Branched Chain



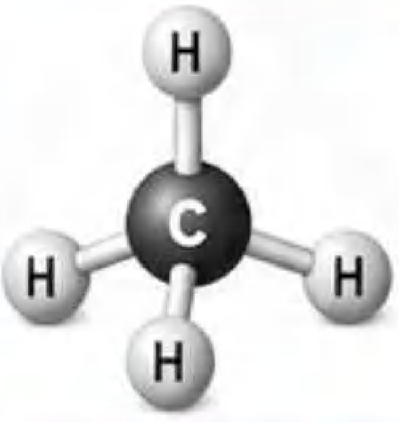
A carbon chain with one or more branches.

Ring Structure

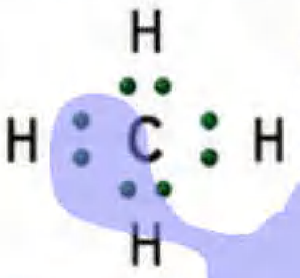


Carbons linked in a ring.

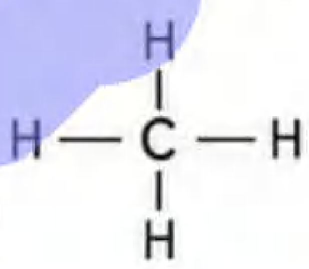
Example: Methane (CH_4)



Lewis-dot structure



Line-bond structure



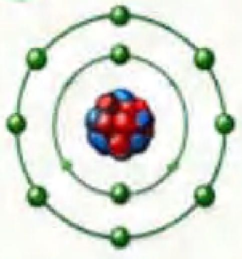
Methane (CH_4) is one of the simplest organic compounds.

Why carbon is important

1. Forms many compounds with different elements.
2. Builds the backbone of organic molecules.
3. Can link to itself in different patterns to create vast diversity.

2. Lesson Review: What We Learned

1 Valence Electrons and Stability



Valence electrons determine how atoms bond. Atoms seek full outer shells (octet or duet) for stability.

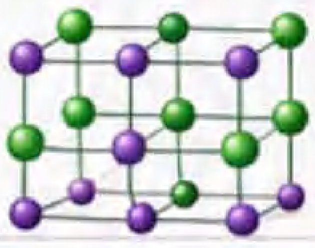
2 Ion Formation

$Na\bullet \longrightarrow Na^+ + e^-$

$:\ddot{\underset{..}{Cl}}\cdot + e^- \longrightarrow :\ddot{\underset{..}{Cl}}:$

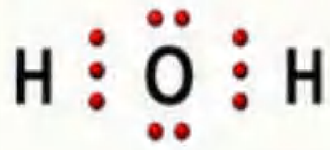
Atoms can lose or gain electrons to become ions with full outer shells.

3 Ionic Bonds and Ionic Compounds



Cations and anions attract each other, forming ionic bonds and ionic compounds.

4 Covalent Bonds and Shared Electrons



$H:\ddot{\underset{..}{O}}:H$

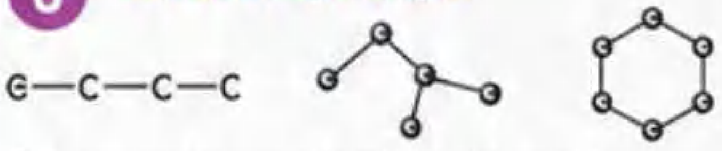
Atoms share electrons to form covalent bonds and molecules.

5 Ionic vs. Covalent Properties

Ionic compounds: high melting points, brittle, often soluble in water.

Covalent compounds: lower melting points, often gases, liquids, or soft solids.

6 Carbon Structures



Carbon can form straight chains, branched chains, and rings—building countless organic molecules.

BIG IDEA Understanding how electrons behave helps explain bonding, properties of compounds, and the diversity of materials.

REMEMBER Chemistry connects structure, bonding, and properties.

Science Theater

ELECTRIC FORCES

Static Electricity

1/10

Science Field: Physics

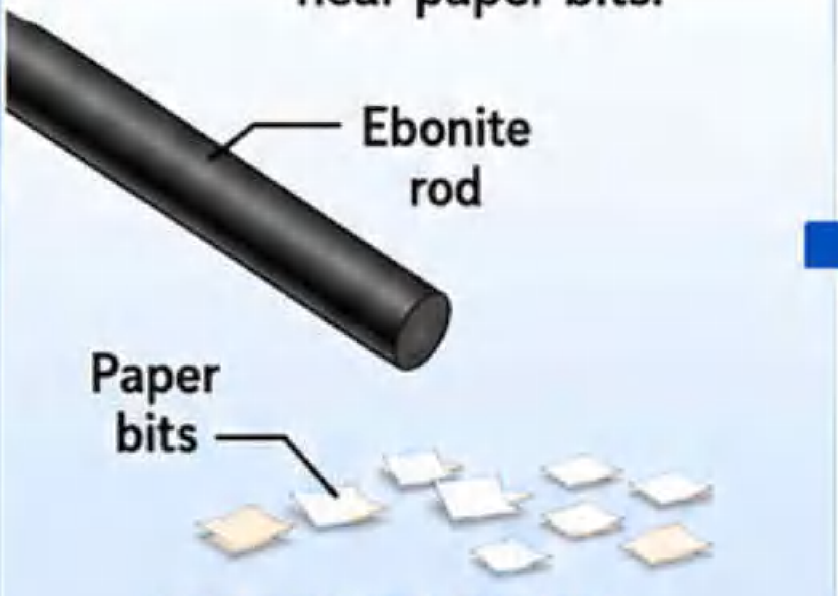
Topic: Static Electricity

KEY CONCEPT Static electricity is the accumulation of electric charges on the surface of an object.

1. Charging by Friction

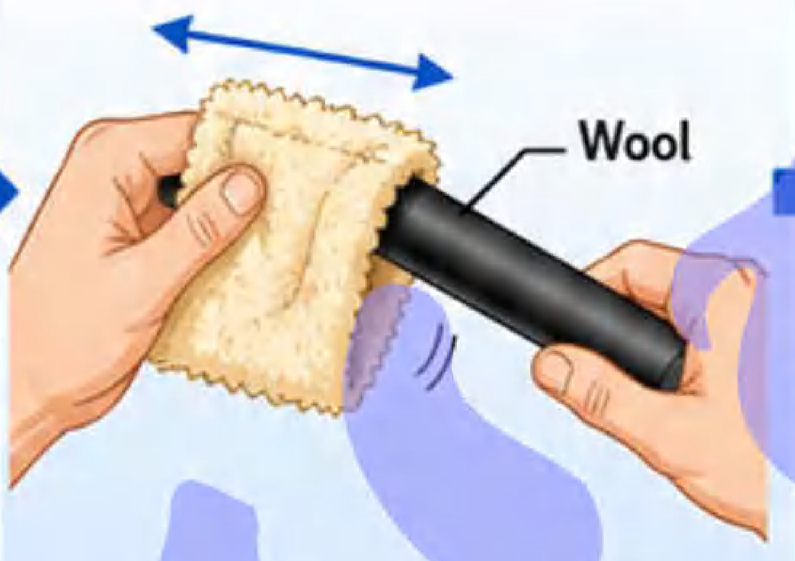
Let's do a simple experiment to see static electricity in action.

① Ebonite rod before rubbing near paper bits.

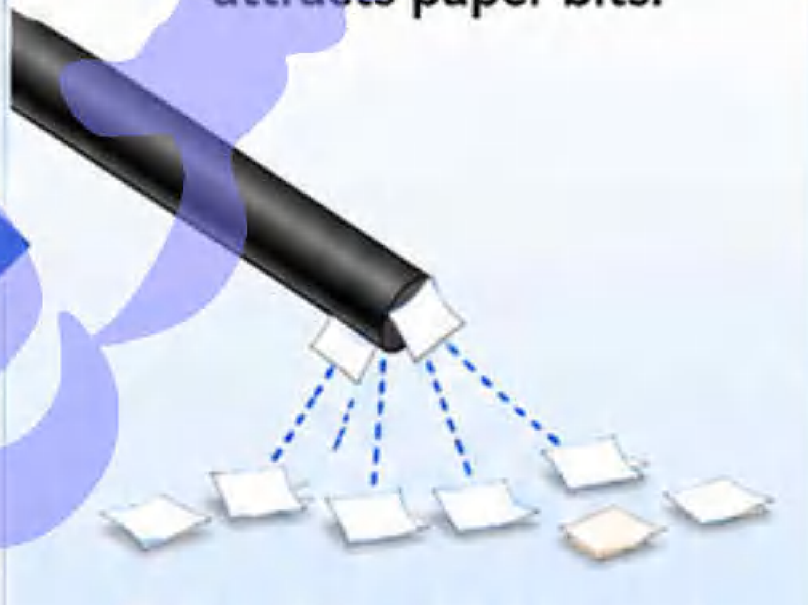


No attraction.

② Rub the ebonite rod with wool.



③ Rubbed ebonite rod attracts paper bits.



Attraction observed.

Observation: After rubbing, the ebonite rod attracts the small paper bits.

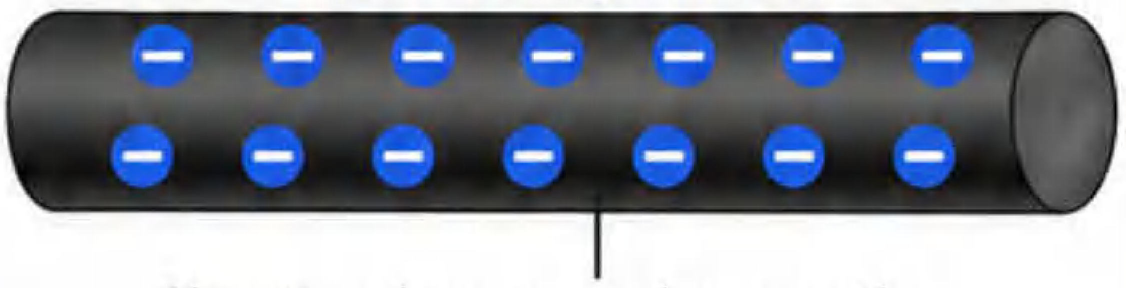
Conclusion: Rubbing the ebonite rod with wool charges it. The charged rod can attract light objects like paper bits.

2. What is Charging by Friction?

Charging by friction is the process of giving an object an electric charge by rubbing it with another material.

When an object is charged by friction, electric charges (positive or negative) collect on its **outer surface.**

Charge buildup on an ebonite rod (after rubbing with wool)



Negative charges are shown on the surface of the rod.

REMEMBER

1. Static electricity forms by friction.
2. Charges accumulate on the surfaces of objects.
3. Charged objects can attract light neutral objects.

Science Theater

ELECTRIC FORCES

Conductors and Insulators

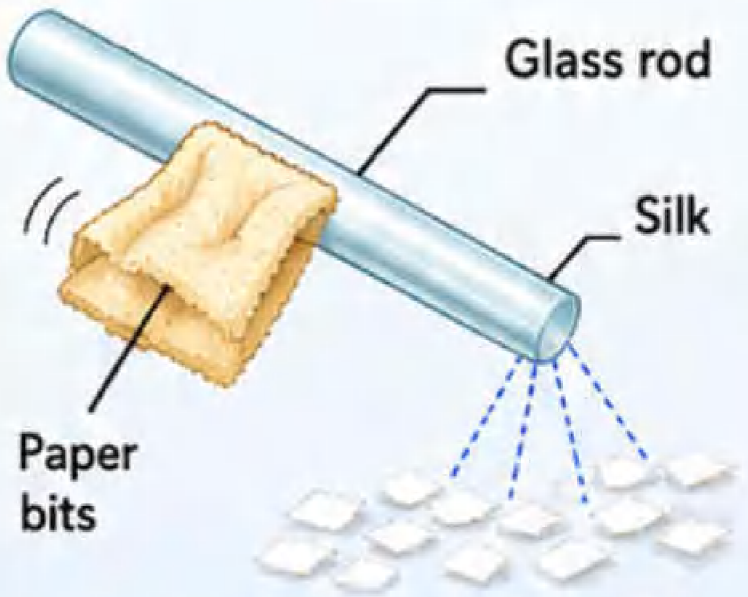
Science Field: Physics

Topic: Charge Movement in Materials

KEY CONCEPT Conductors allow electric charges to move through them, while insulators do not.

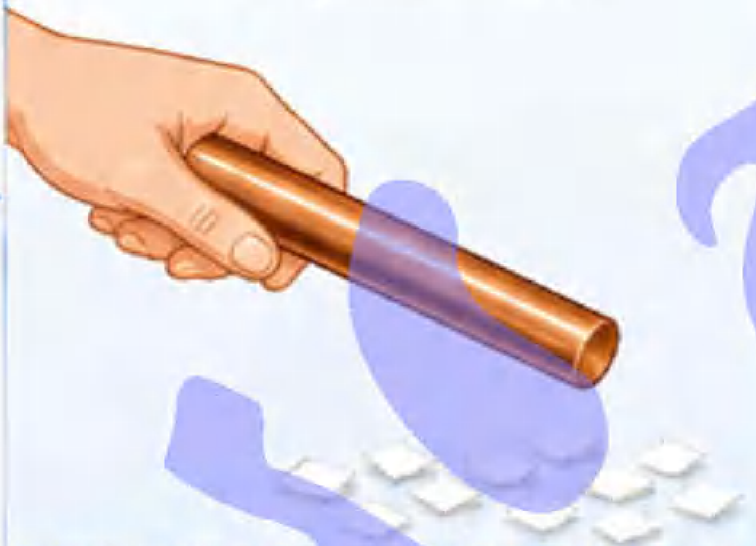
1. Comparing a Glass Rod and a Copper Rod

A A glass rod rubbed with silk can keep charge and attract paper bits.


Glass rod
Silk
Paper bits

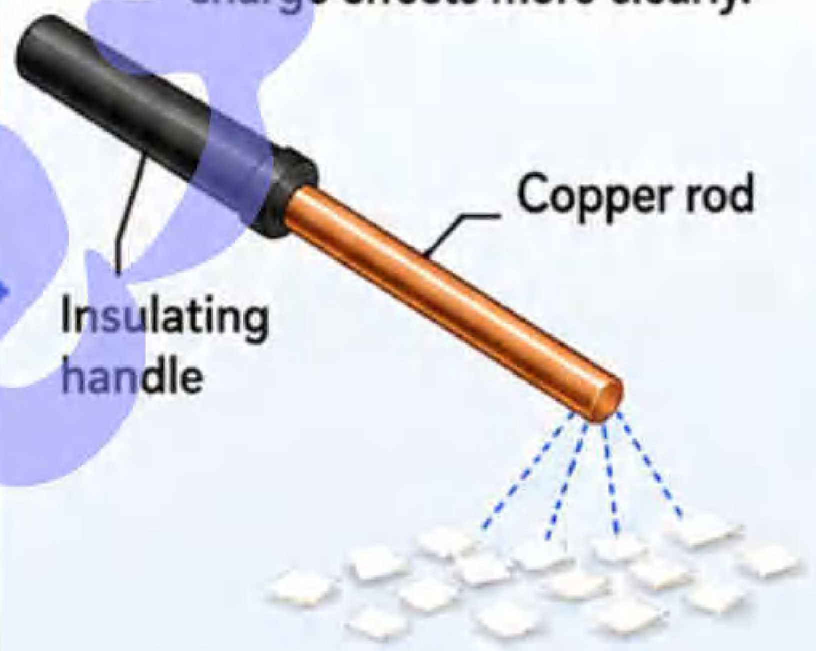
Attraction observed.

B A copper rod held by hand does not keep charge well because charge can leak through the hand.



No or weak attraction.
Charge leaks through the hand.

C A copper rod held with an insulating handle can show charge effects more clearly.

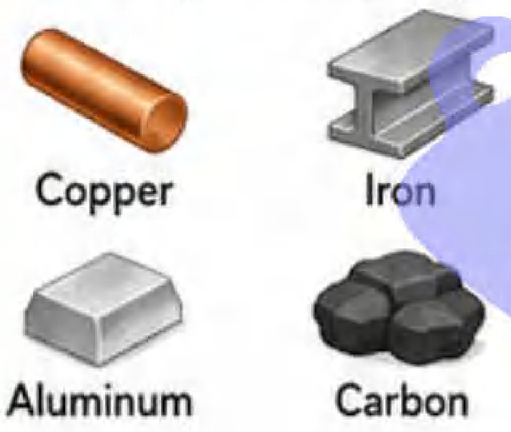

Copper rod
Insulating handle

Attraction observed.

2. Classifying Materials

Conductors

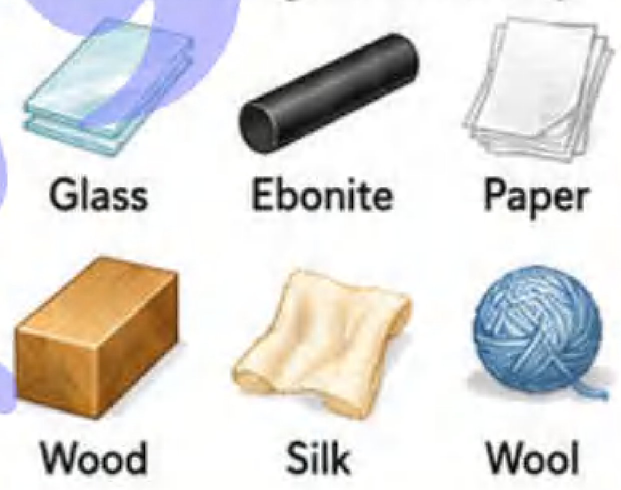
Allow charges to move through them easily.


Copper
Iron
Aluminum
Carbon

All metals

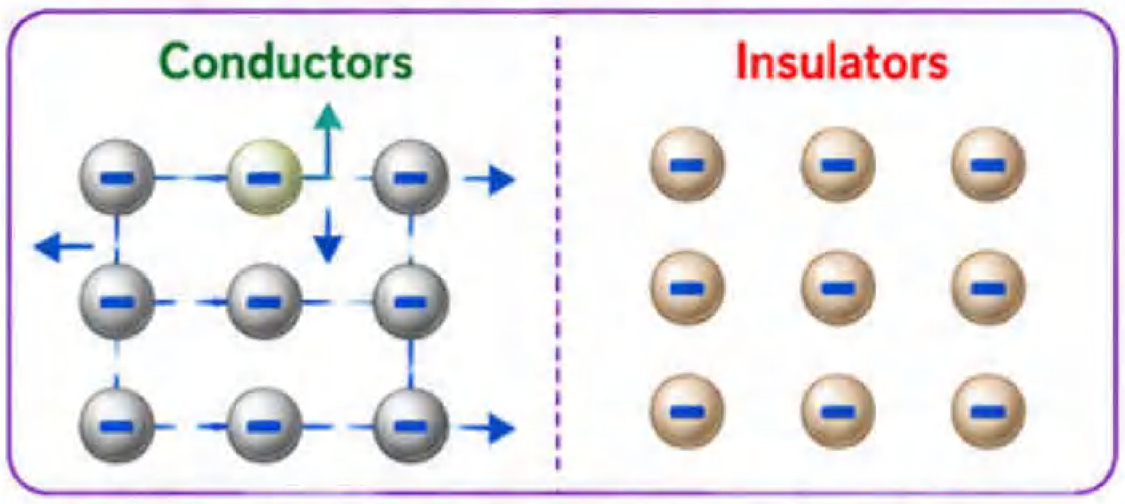
Insulators

Do not allow charges to move through them easily.


Glass
Ebonite
Paper
Wood
Silk
Wool

3. Why the Difference?

In conductors, charges can move freely through the material, so they spread out.


Conductors
Insulators

In insulators, charges are more tightly held in place and remain more localized.

REMEMBER

1. Metals are **conductors.** They let charges move through them.
2. Glass and ebonite are **insulators.** They do not let charges move easily.
3. Insulating handles help prevent charge leakage and make charging effects more visible.

ELECTRIC FORCES

How Objects Become Charged

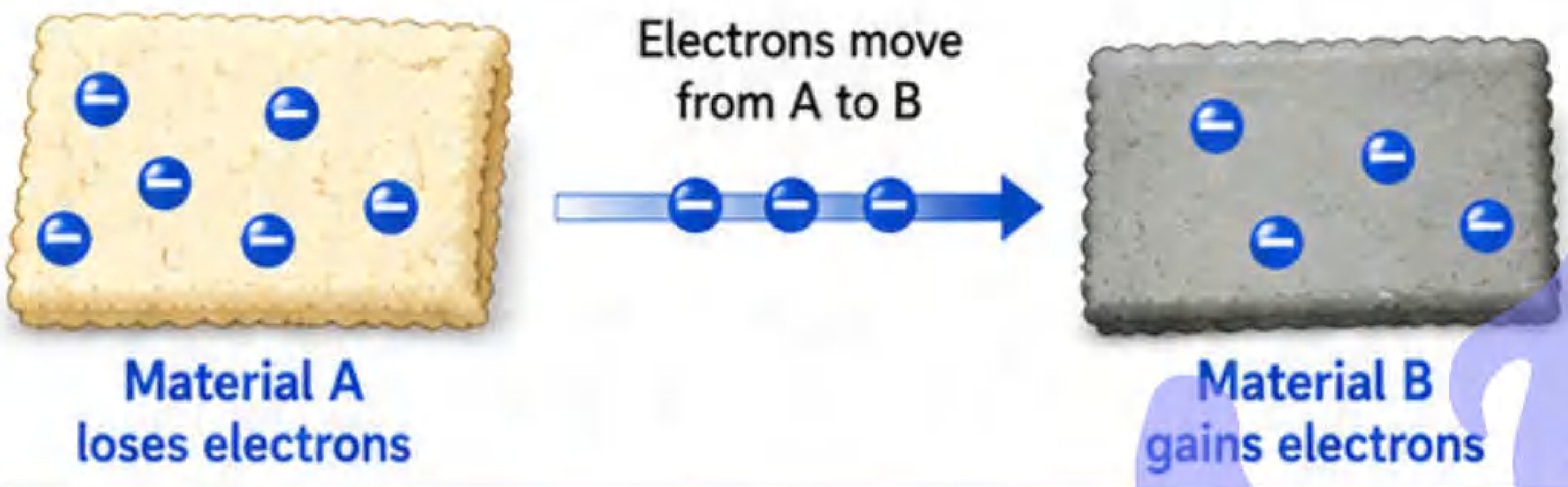
Science Field: Physics

Topic: Transfer of Electrons

KEY CONCEPT Objects become electrically charged when electrons move from one material to another.

1. What Happens During Rubbing?

When two materials are rubbed together, electrons transfer from one surface to the other.

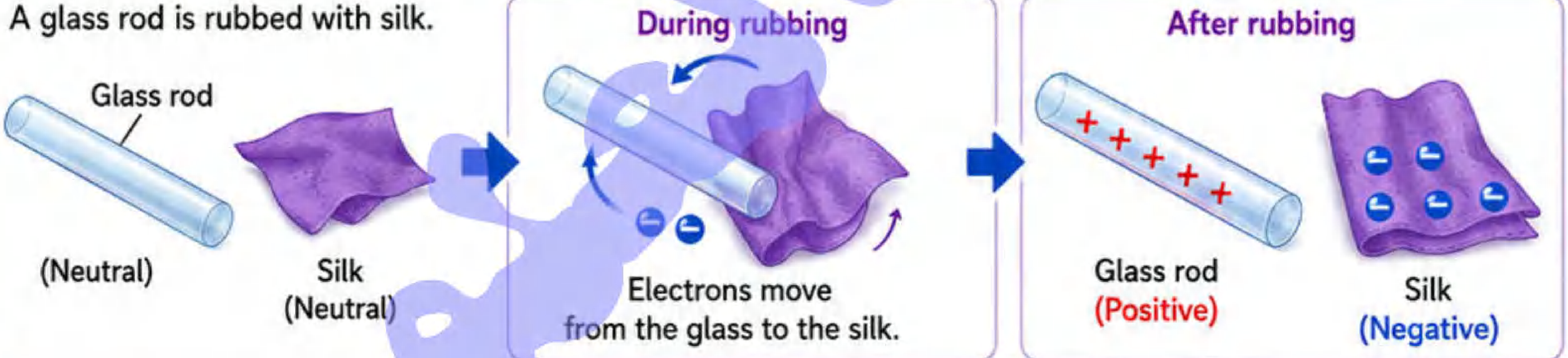

Electrons move
from A to B
Material A
loses electrons
Material B
gains electrons

Loses electrons → Positive charge ⊕

Gains electrons → Negative charge ⊖

2. Worked Example: Glass and Silk

A glass rod is rubbed with silk.


During rubbing
After rubbing
Glass rod
(Neutral)
Silk
(Neutral)
Electrons move
from the glass to the silk.
Glass rod
(Positive)
Silk
(Negative)

3. Static Electricity (Electrostatics)

Static electricity (electrostatics) is the accumulation of electric charges on an object due to the gain or loss of electrons.

Unit of Electric Charge
The SI unit of electric charge is the **Coulomb (C).**

Charles-Augustin de Coulomb
The unit of electric charge, the coulomb (C), is named after him.

REMEMBER

1. Loss of electrons leads to a positive charge.
2. Gain of electrons leads to a negative charge.
3. Rubbing different materials can transfer electrons.

Science Theater

ELECTRIC FORCES

The Electrostatic Series

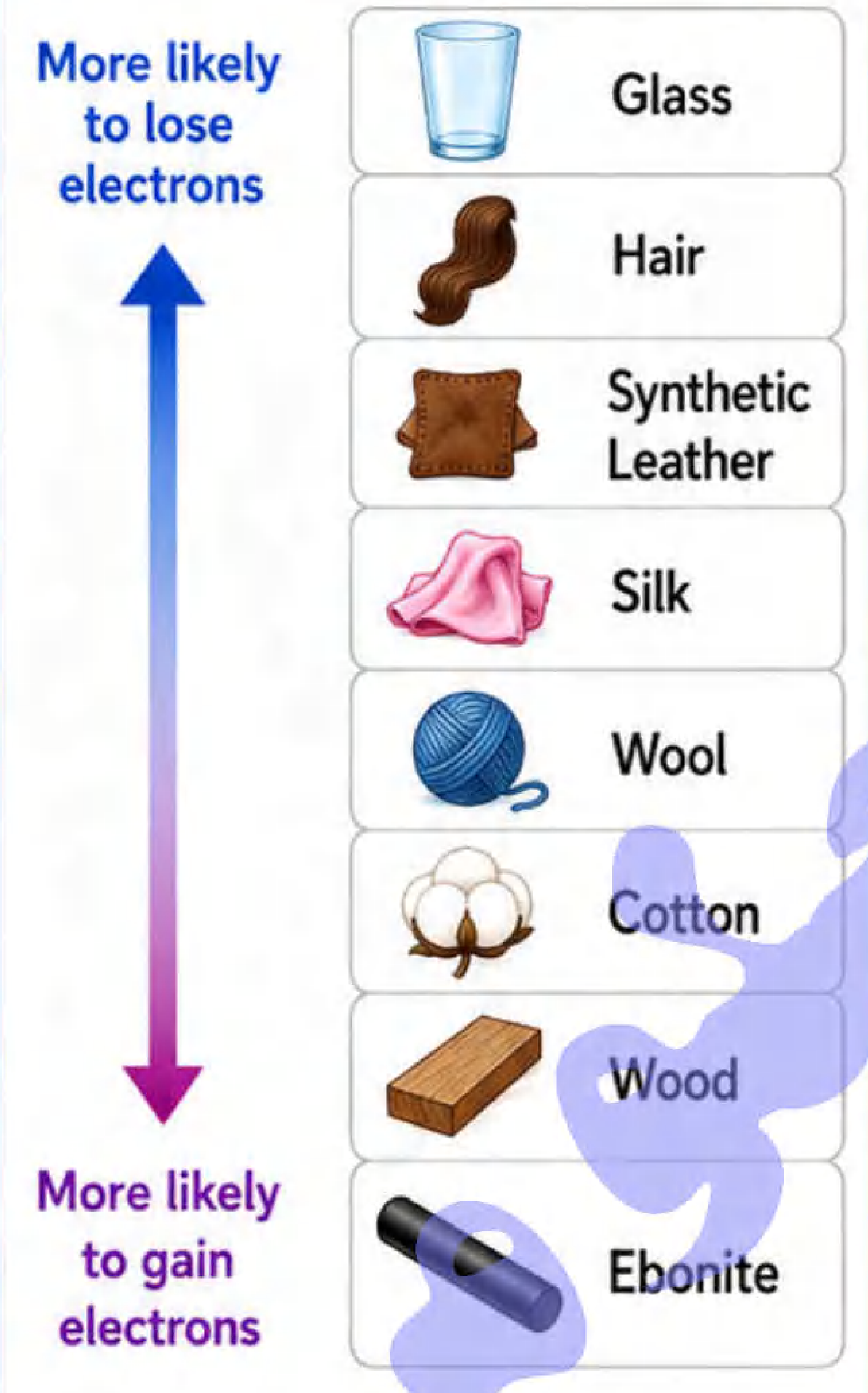
Science Field: Physics

Topic: Tendency to Lose or Gain Electrons

KEY CONCEPT

Different materials have different tendencies to lose or gain electrons when rubbed together.

1. The Electrostatic Series


More likely to lose electrons
Glass
Hair
Synthetic Leather
Silk
Wool
Cotton
Wood
Ebonite
More likely to gain electrons

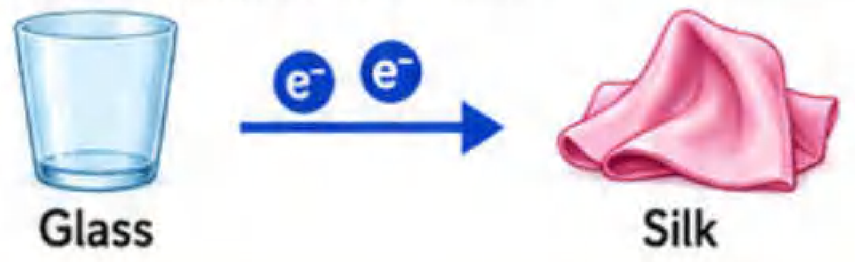
2. How to Predict the Charge

+ The material higher in the series tends to lose electrons and become positively charged.

− The material lower in the series tends to gain electrons and become negatively charged.

3. Examples

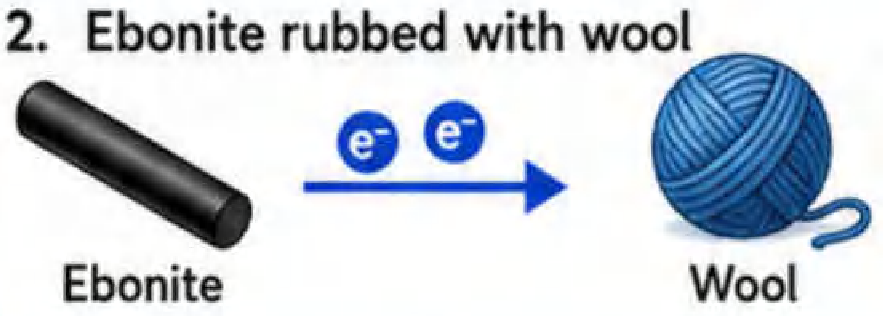
1. Glass rubbed with silk


e⁻ e⁻
Glass
Silk

Glass: (+) positive

Silk: (−) negative

2. Ebonite rubbed with wool


e⁻ e⁻
Ebonite
Wool

Ebonite: (−) negative

Wool: (+) positive

REMEMBER

- The electrostatic series helps predict the type of charge a material will acquire when rubbed with another.
- + Materials near the top of the series tend to lose electrons and become positively charged.
- − Materials near the bottom of the series tend to gain electrons and become negatively charged.

ELECTRIC FORCES

Electric Forces

Science Field: Physics

Topic: Attraction and Repulsion

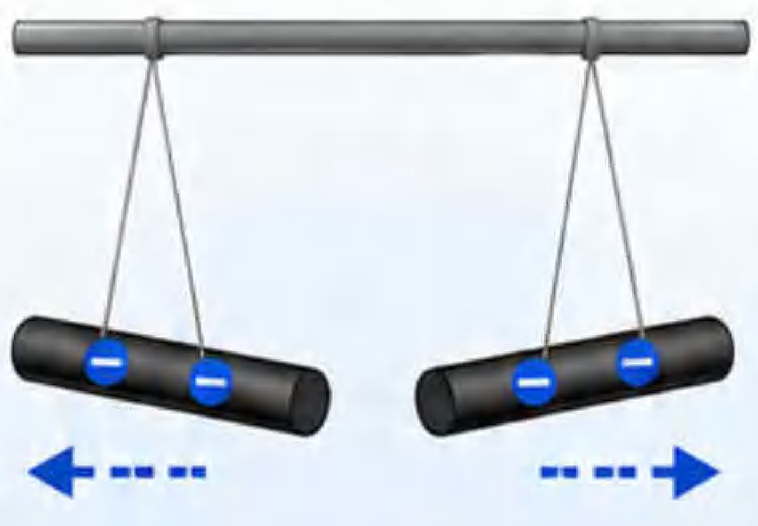
KEY CONCEPT

Like charges repel, unlike charges attract, and a charged object can attract a neutral light object.

1. Forces Between Charged Objects

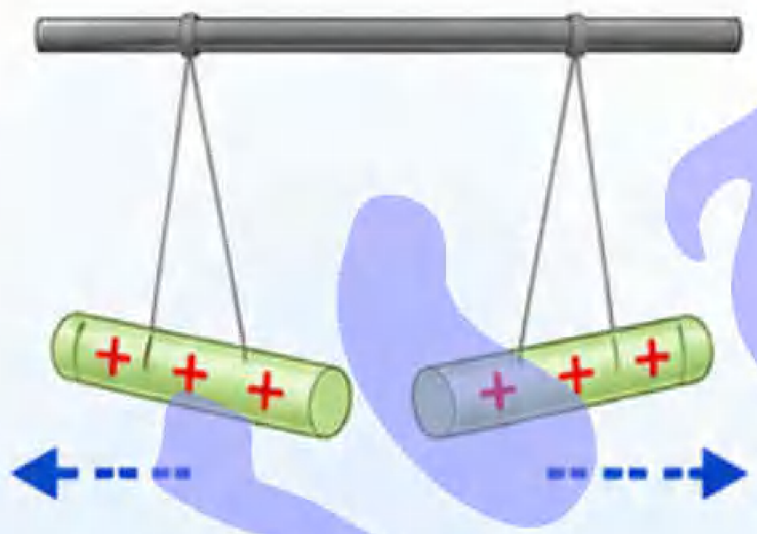
Charge two rods in the same or different ways and observe.

A Two negatively charged ebonite rods repel.



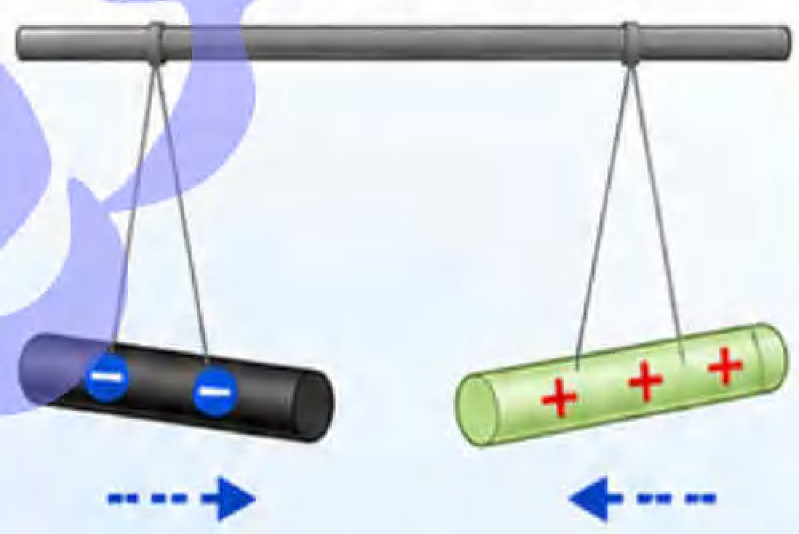
repel

B Two positively charged glass rods repel.



repel

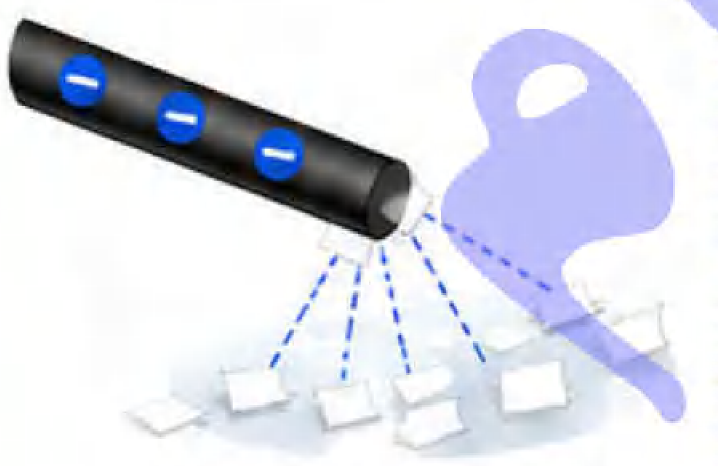
C A negatively charged ebonite rod and a positively charged glass rod attract.



attract

2. Neutral Objects Can Be Attracted

A charged rod can attract paper bits or other neutral light objects.



Charged rod attracting paper bits.

This happens because the charges inside the neutral object rearrange. The side closer to the rod becomes oppositely charged and is pulled in.

3. Rules of Electric Forces

Situation	Result
Like charges (+/+ or -/-) ⊕ ⊕ or ⊖ ⊖	**Repulsion** (push apart) ← →
Unlike charges (+/-) ⊖ or ⊕	**Attraction** (pull together) → ←

REMEMBER

1. Similar charges repel (push apart).
2. Opposite charges attract (pull together).
3. Charged objects may attract neutral light materials.

Science Theater

ELECTRIC FORCES

Static Electricity in Everyday Life

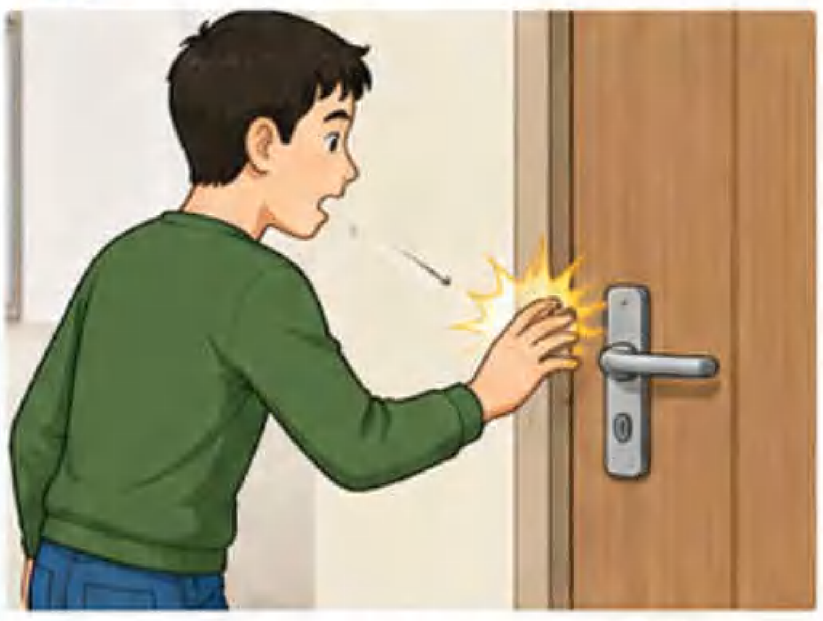
Science Field: Physics

Topic: Applications and Safety

KEY CONCEPT

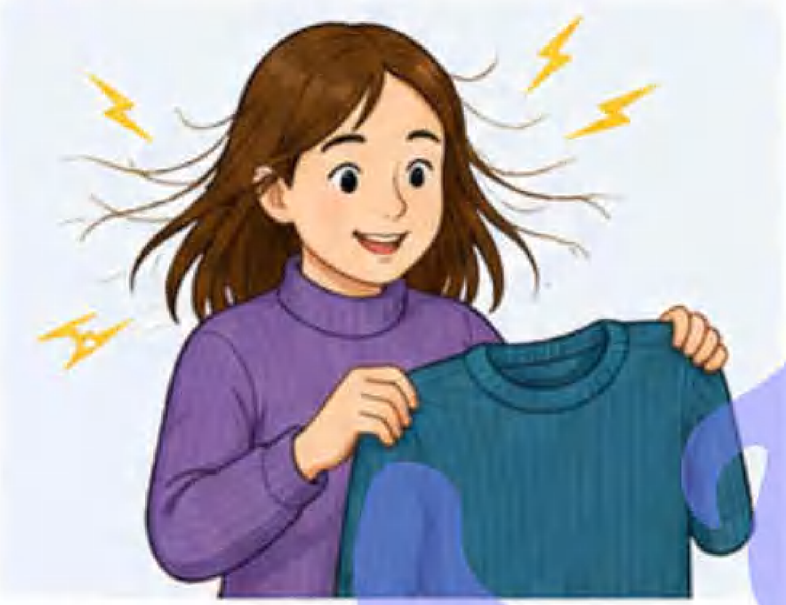
Static electricity appears in daily life and can be useful or dangerous depending on the situation.

1 Door Handle Shock



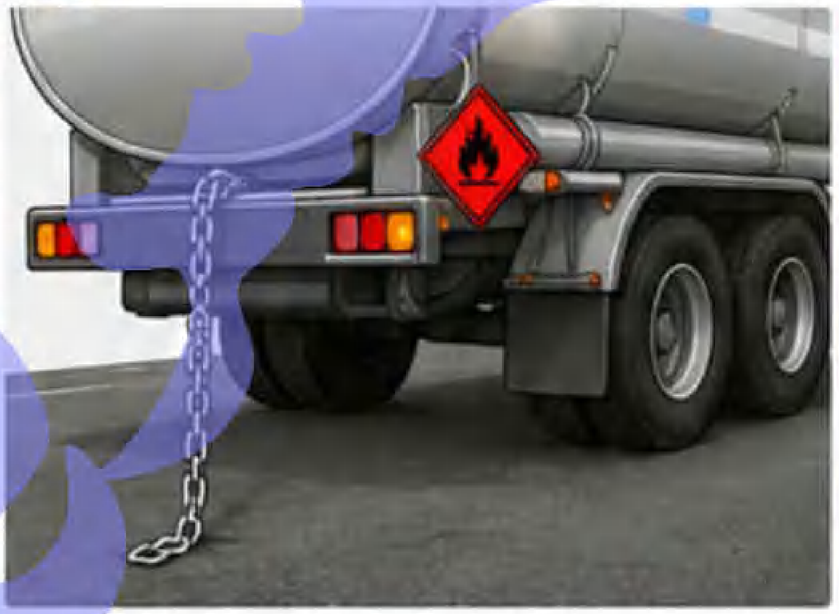
After walking on carpet, your body builds up static charge. Touching a metal door handle can cause a small spark or shock.

2 Clothes in Winter



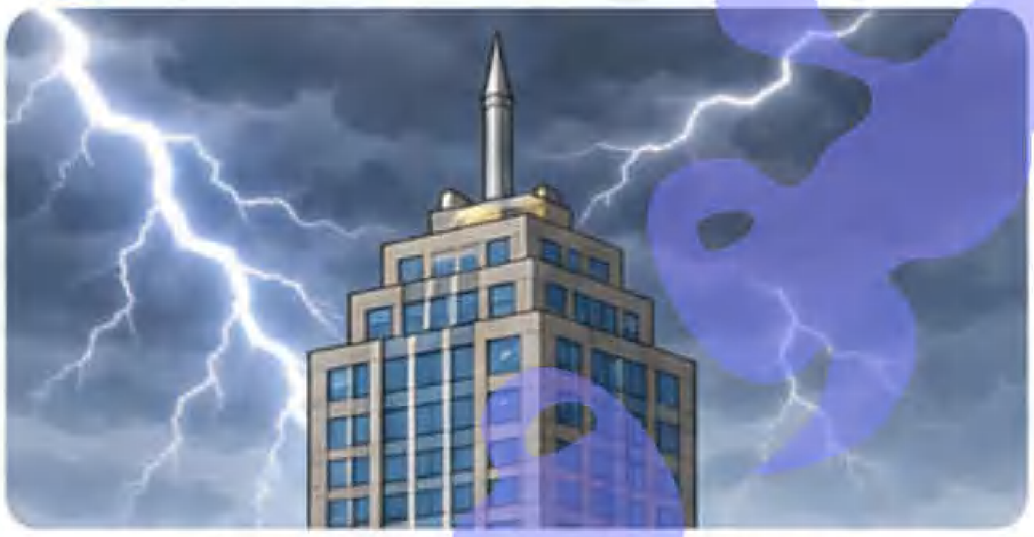
Static charges build up on your clothes, causing them to stick together or to your body and sometimes make a crackling sound.

3 Fuel Trucks



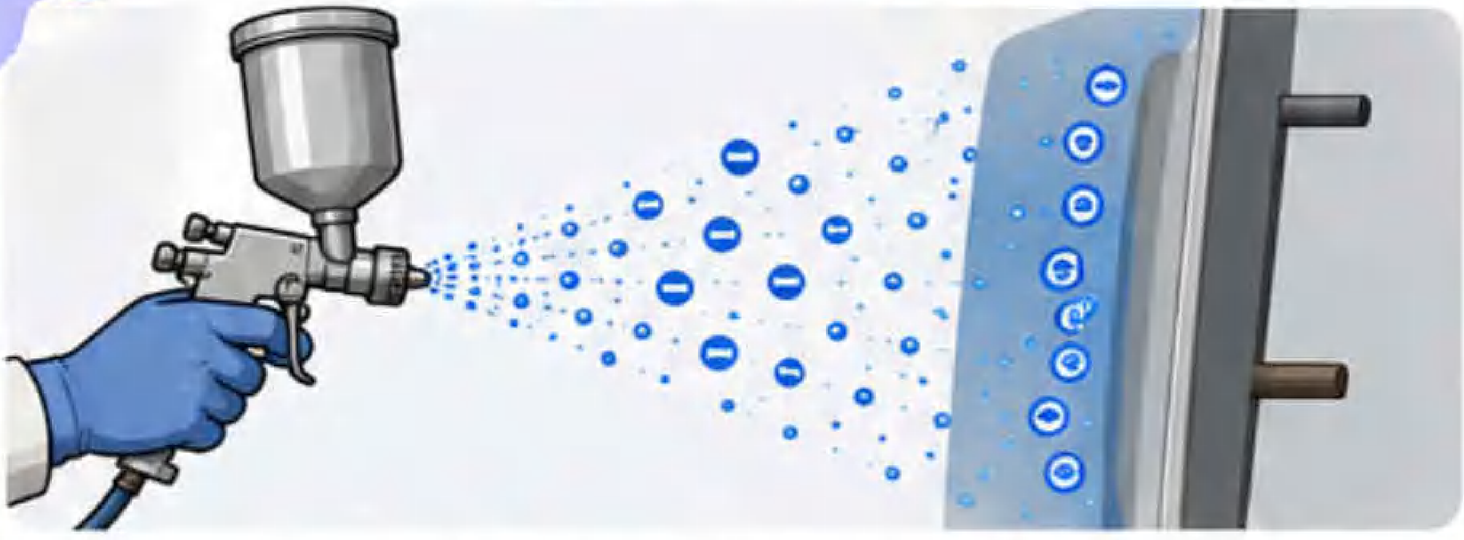
Metal chains hang down and touch the ground to discharge static electricity and reduce the risk of sparks that could cause a fire.

4 Lightning Rod



Lightning rods on tall buildings attract lightning and safely direct the electric discharge to the ground, protecting the structure.

5 Electrostatic Painting



Paint droplets are given an electric charge as they spray. They are attracted to the object, giving a uniform coat with less overspray and less waste.

Why It Matters

Static electricity is all around us. It can cause sparks, shocks, or equipment problems—but it also has many useful applications that make our lives safer and more efficient.

REMEMBER

1. Static electricity can build up in daily life.
2. Grounding improves safety.
3. Electrostatic painting is a useful application.

Science Theater

ELECTRIC FORCES

The Electric Field

7/10

Science Field: Physics

Topic: Electric Field and Field Lines

KEY CONCEPT

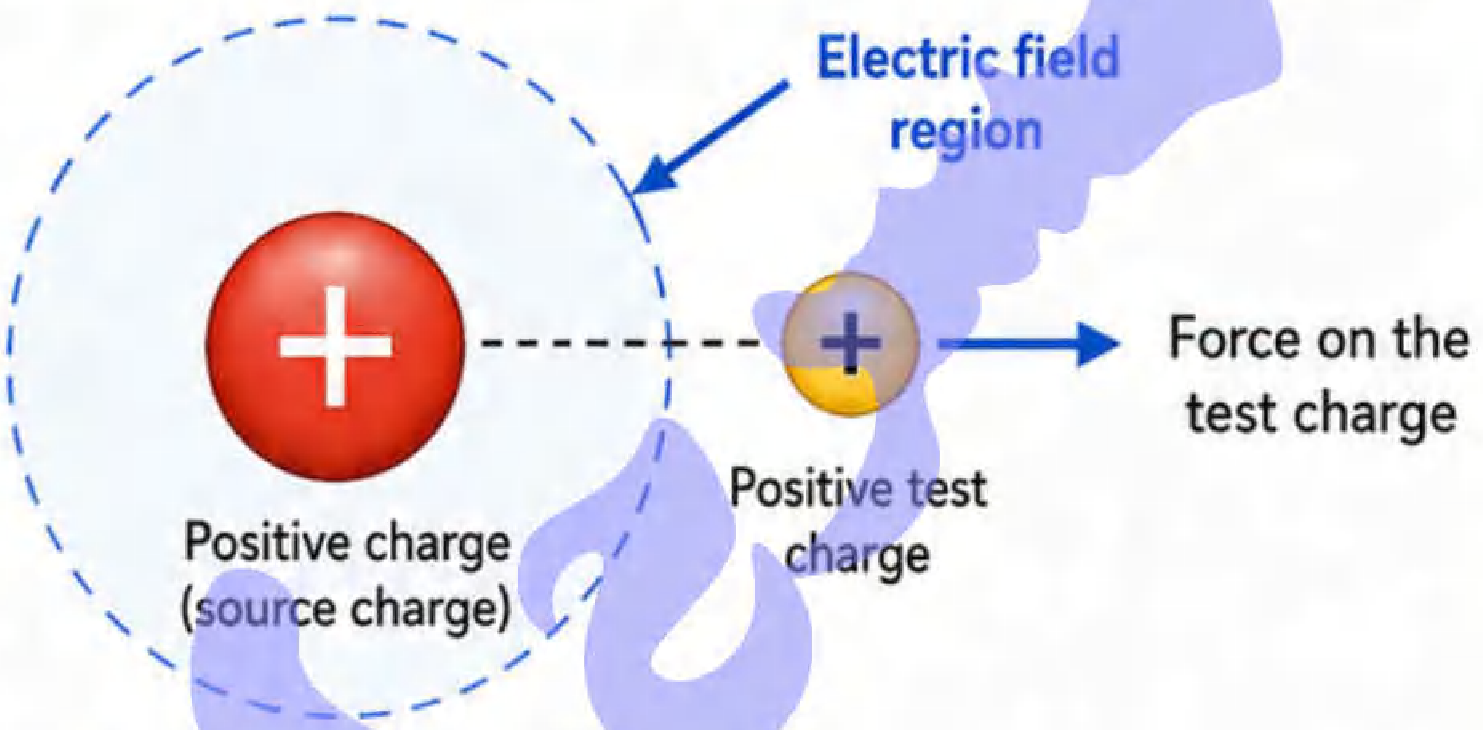
An electric field is the region around a charge where electric forces can act on other charges.

1. What Is an Electric Field?

A charged object creates an electric field in the space around it.

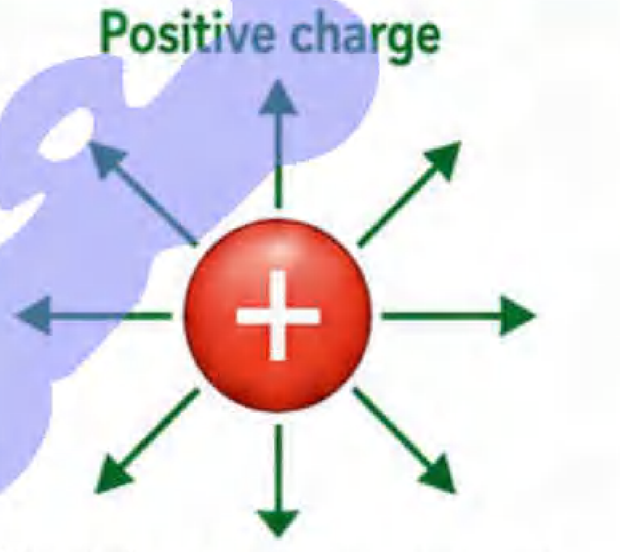
If a small positive test charge is placed in this region, it feels a force.

An electric field is the area around a charge where its effect is noticed.

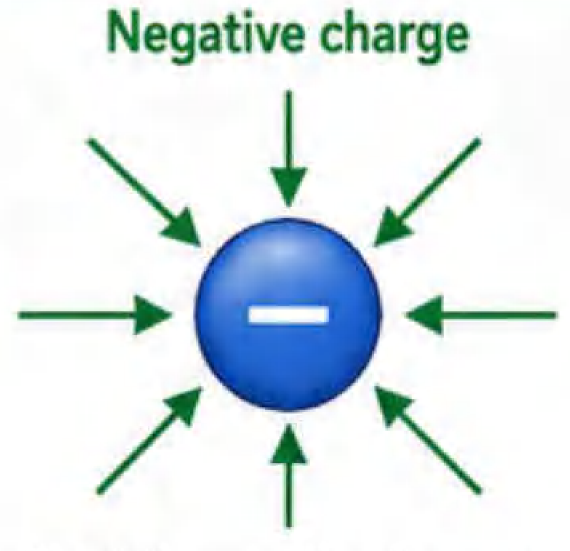

Electric field region
+
Positive charge (source charge)
+
Positive test charge
Force on the test charge

2. Electric Field Lines

Electric field lines are imaginary lines used to represent the direction of the electric force created by a charge.


Positive charge
+

Field lines point outward (away from positive charge).


Negative charge
−

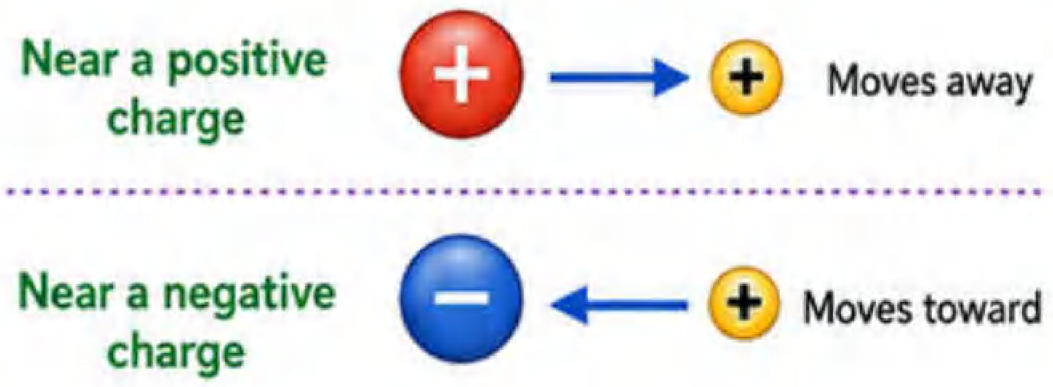
Field lines point inward (toward negative charge).

3. Reading the Direction

The direction of the electric field is the direction a positive test charge would move if placed in the field.

RULE TO REMEMBER

Electric field lines point in the direction a small positive test charge would move.


Near a positive charge
+
+
Moves away
Near a negative charge
−
+
Moves toward

REMEMBER

1. Electric fields surround charges and extend through space.
2. Field lines show the direction of the electric force.
3. A positive test charge moves in the direction of the field lines.

Science Theater

ELECTRIC FORCES

8/10

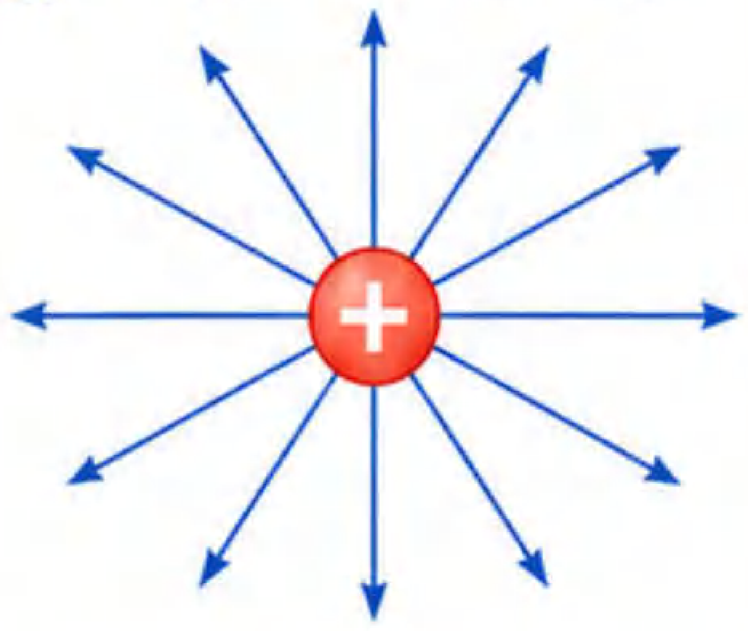
Electric Field-Line Patterns

Science Field: Physics

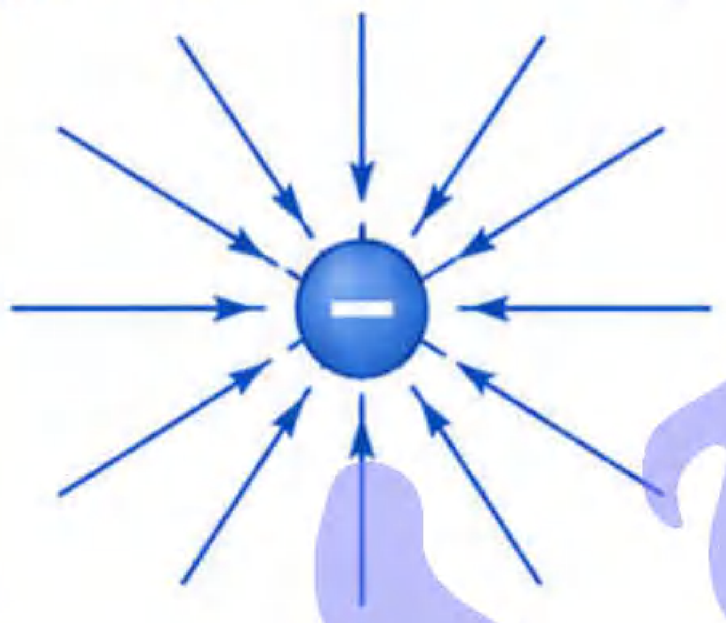
Topic: Shapes of Field Lines

KEY CONCEPT Field-line patterns help us visualize the electric field around single charges, pairs of charges, and charged plates.

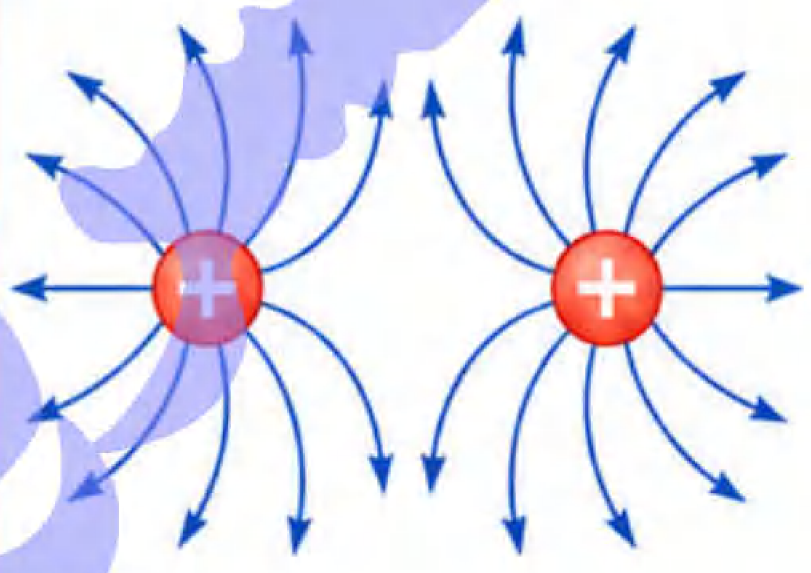
① Single Positive Charge



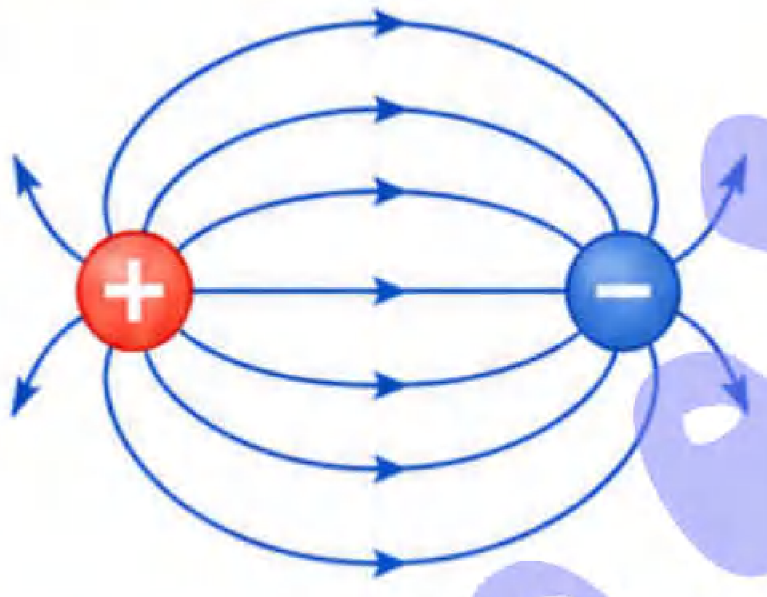
② Single Negative Charge



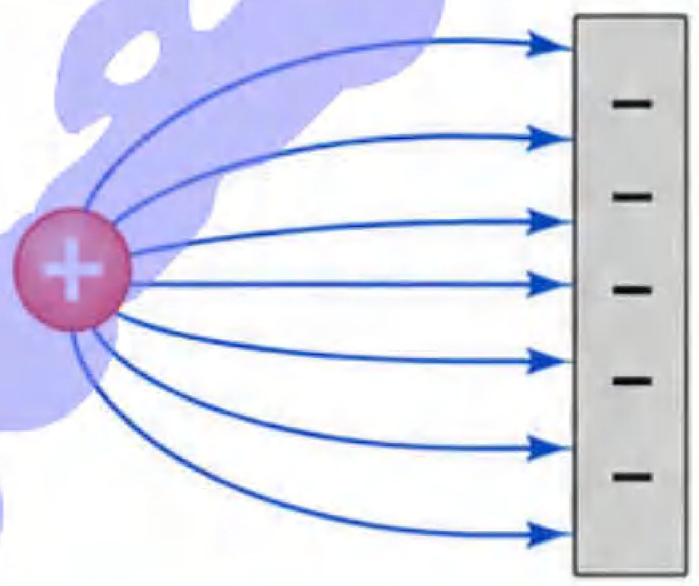
③ Two Like Charges



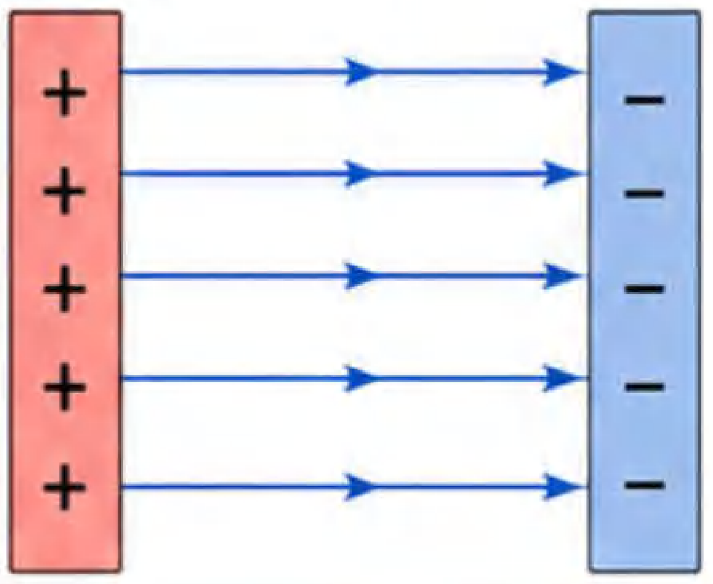
④ Two Opposite Charges



⑤ Point Charge and Oppositely Charged Plate



⑥ Two Oppositely Charged Parallel Plates



Properties of Field Lines

- Field lines are **imaginary**. They are used to represent the electric field.
- Field lines **never intersect**. If they did, it would mean the field has two directions at one point, which is not possible.
- Field lines **begin on positive** charges and **end on negative** charges.
- The **closer (denser)** the field lines, the **stronger** the electric field in that region.

ELECTRIC FORCES

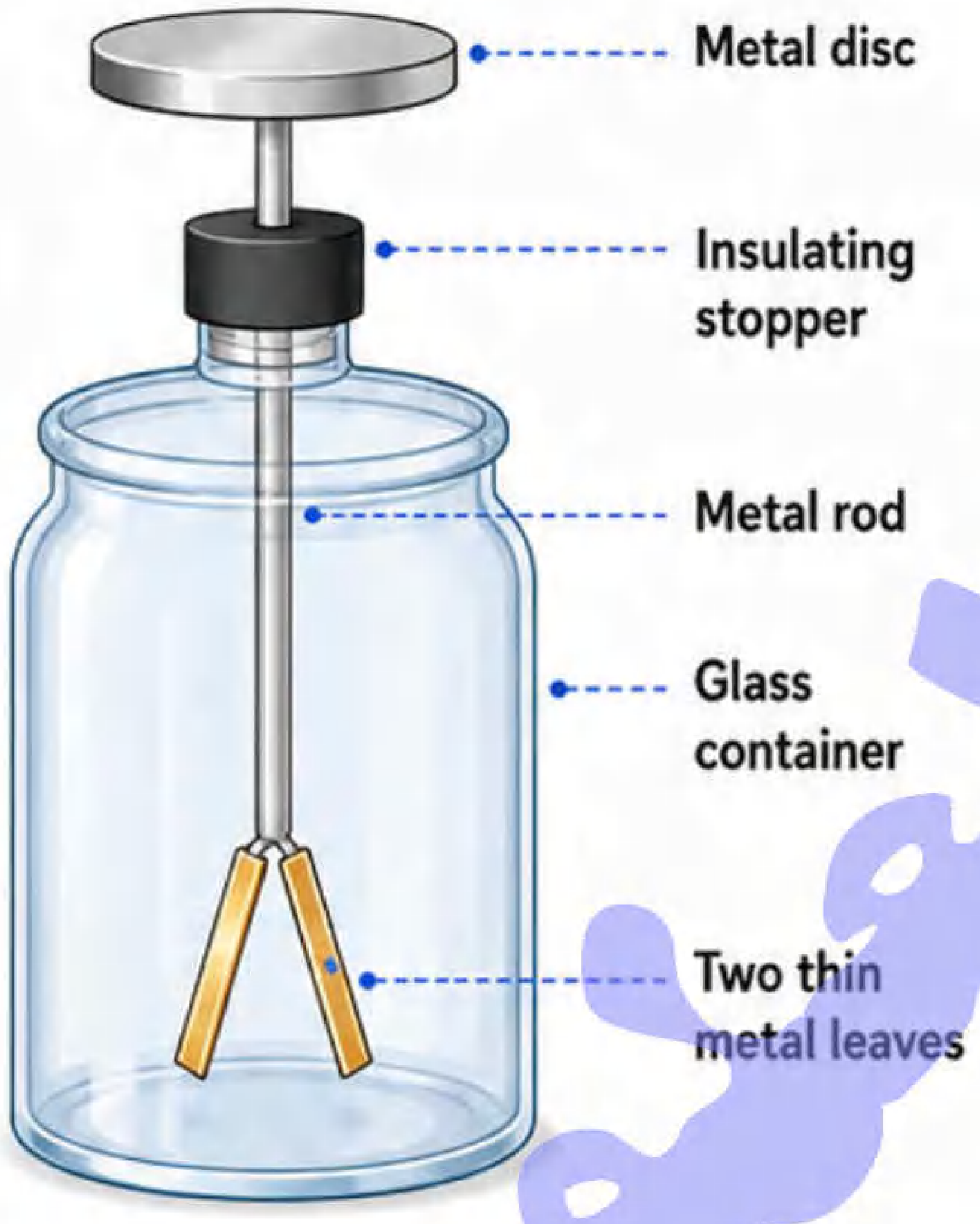
The Electroscope

Science Field: Physics

Topic: Detecting Electric Charge

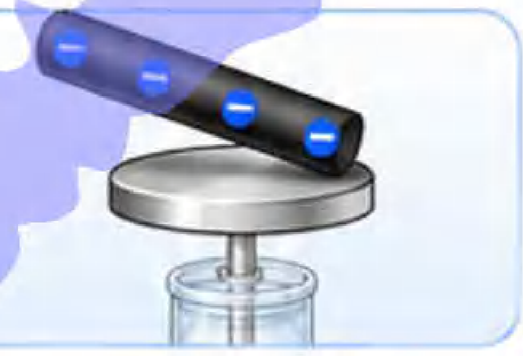
KEY CONCEPT An electroscope is a device used to detect whether an object is electrically charged.

1. Parts of an Electroscope

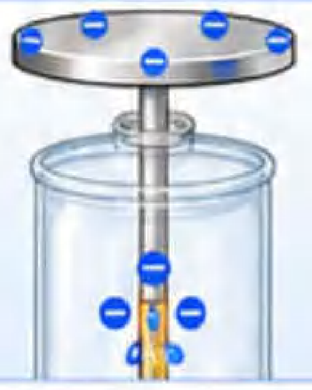


2. How It Works

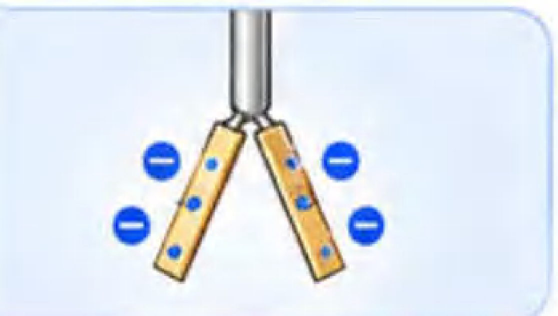
① Touch the metal disc with a charged object.



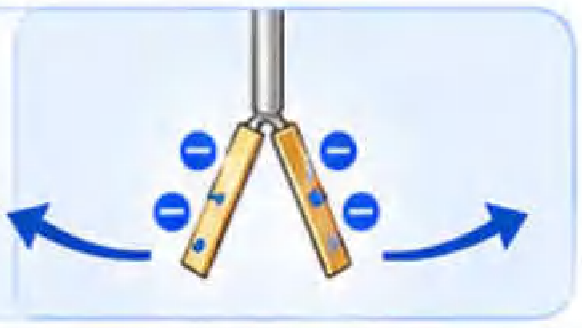
② The charge spreads through the metal rod and into the leaves.



③ The two leaves get the same type of charge.



④ Like charges repel each other, so the leaves diverge.



3. What Does Divergence Mean?

If the leaves of an electroscope diverge, it means the tested object is electrically charged.

NOTE:
When an object touches the electroscope (charging by contact), some charge transfers to the electroscope. That charge then spreads to the leaves.

REMEMBER

1. Electroscopes are used to detect whether an object is charged.
2. Like charges on the leaves repel each other.
3. Leaf divergence is the visible sign that the object is charged.

ELECTRIC FORCES

Using the Electroscope & Final Review

Science Field: Physics

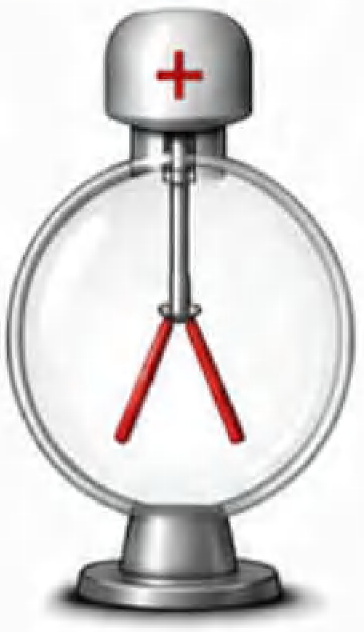
Topic: Charge Type and Lesson Review

KEY CONCEPT A charged electroscope can help determine whether another object has the same charge, the opposite charge, or a larger amount of charge.

1. Determining the Type of Charge

Use a known positively charged electroscope as reference.

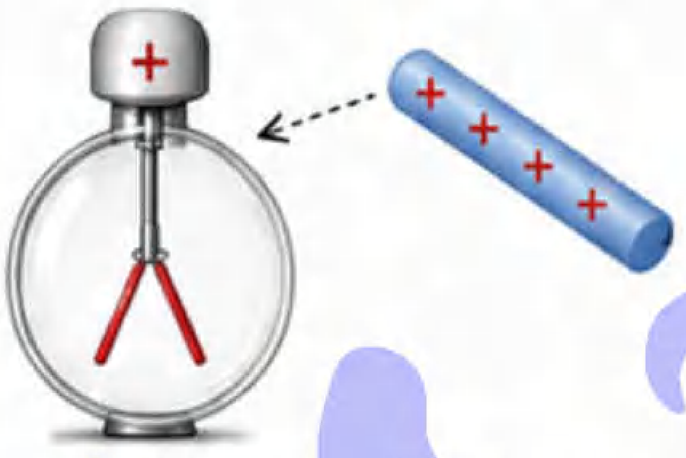
Reference: Positively Charged Electroscope



The leaves diverge because the electroscope is positively charged.

Case A: Positive Object

Bringing a positively charged object near the electroscope

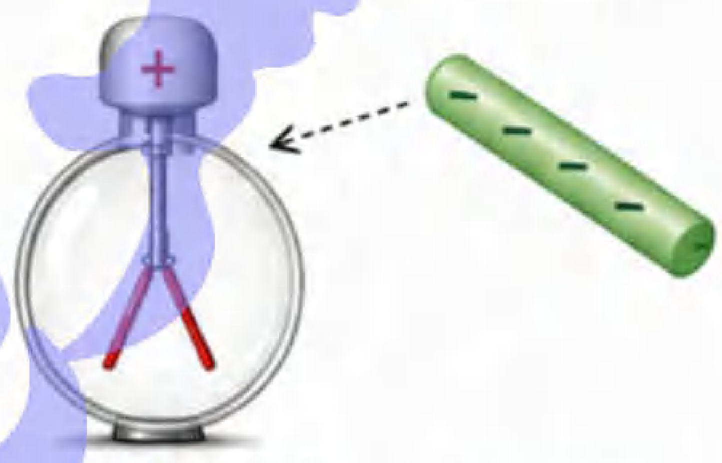


➡ The leaves diverge more.

Same type of charge.

Case B: Negative Object

Bringing a negatively charged object near the electroscope



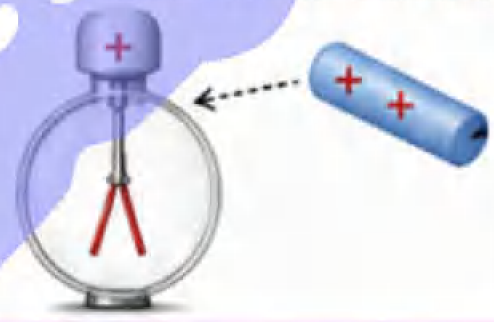
➡ The leaves diverge less.

Opposite type of charge.

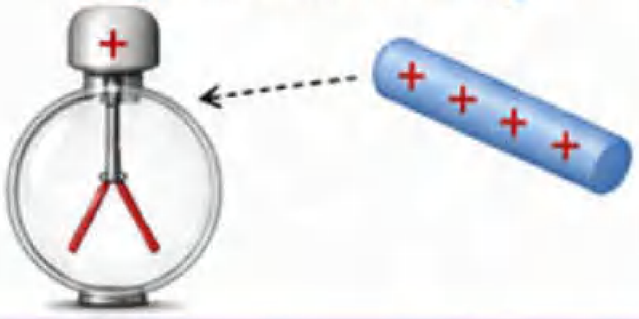
2. Comparing Amount of Charge

A greater leaf divergence means a greater effect on the electroscope (larger amount of charge).

Smaller Amount of Charge



Larger Amount of Charge



3. Final Review: What We Learned

1. Static Electricity
Charges can build up on objects and create forces when they are at rest.

2. Conductors vs. Insulators
Conductors let charge move easily.
Insulators resist the movement of charge.

3. Electron Transfer
Objects become charged when electrons transfer from one object to another.

4. Electrostatic Series
Materials can tend to lose or gain electrons based on their place in the series.

5. Attraction and Repulsion
+ ↔ +
− ↔ +
Like charges repel.
Opposite charges attract.

6. Electric Field
A charge creates an electric field that exerts a force on other charges.

7. Electroscope An electroscope detects charge and helps determine the type and relative amount of charge.

BIG IDEA Electric charges explain many everyday effects, forces, and devices.

LESSON 1

Magnetic Forces

Magnets: Natural and Artificial

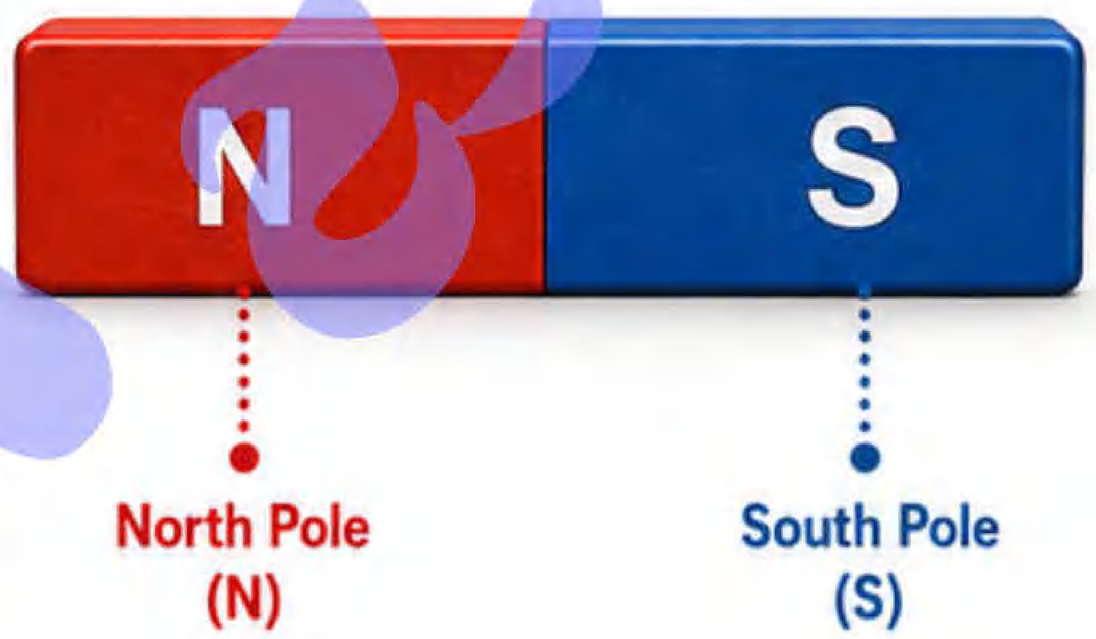
Magnets attract some metallic materials.

A Natural Magnet

- A natural magnet is **lodestone**, also called **magnetite**.
- It can attract some metallic objects.

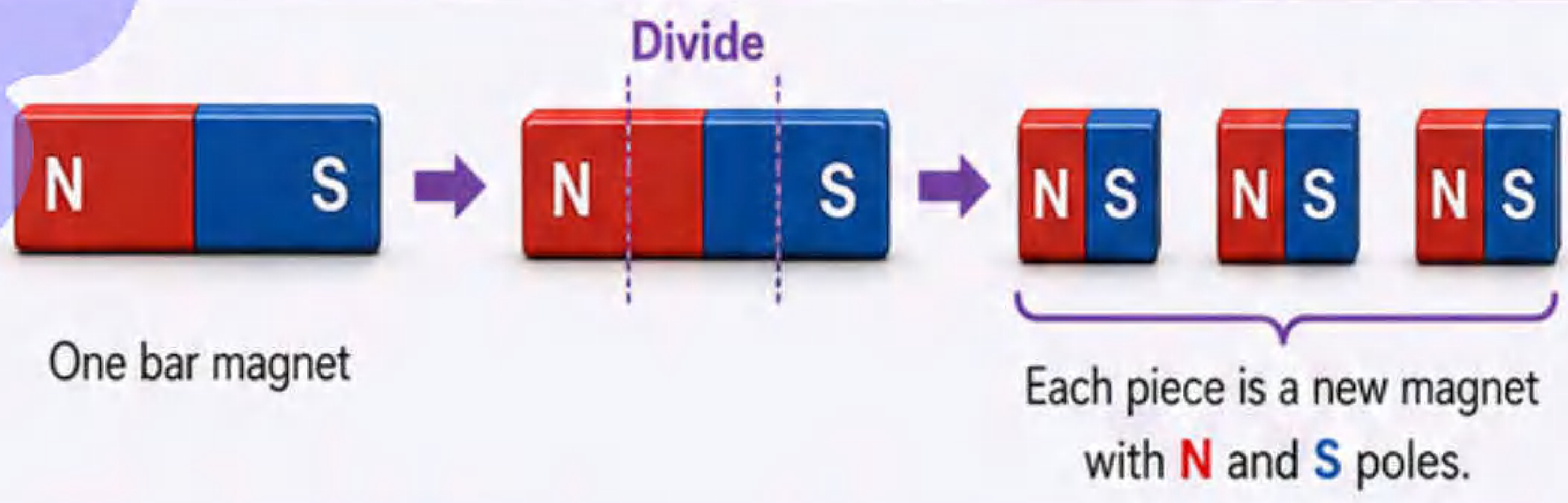
B Artificial Magnet

- Humans manufactured magnets to benefit from magnetic phenomena.



IMPORTANT RULE

- When a magnet is divided into pieces, we **do not** obtain a single magnetic pole.
- Each piece becomes a new magnet with **both** a north pole and a south pole.



Each piece is a new magnet with **N** and **S** poles.

KEY TAKEAWAY – REMEMBER!

There are two types of magnets: **natural** and **artificial**.

Every magnet has two poles: **North (N)** and **South (S)**.

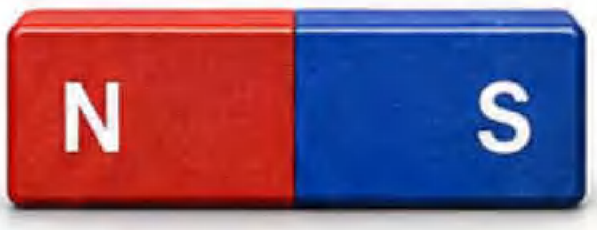
No isolated single magnetic pole can be obtained by dividing a magnet.

LESSON 2

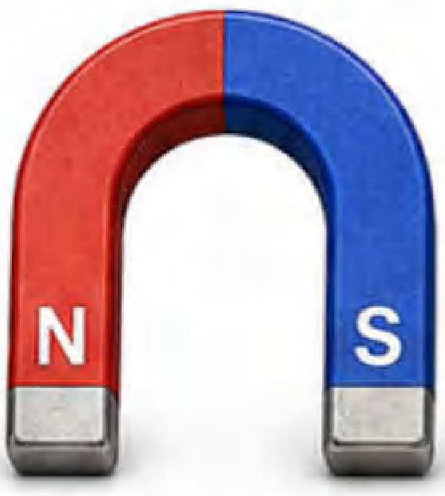
Magnetic Forces

Shapes of Magnets & Magnetic Materials

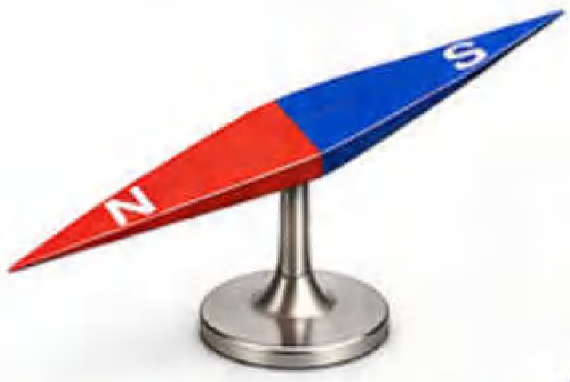
COMMON SHAPES OF ARTIFICIAL MAGNETS



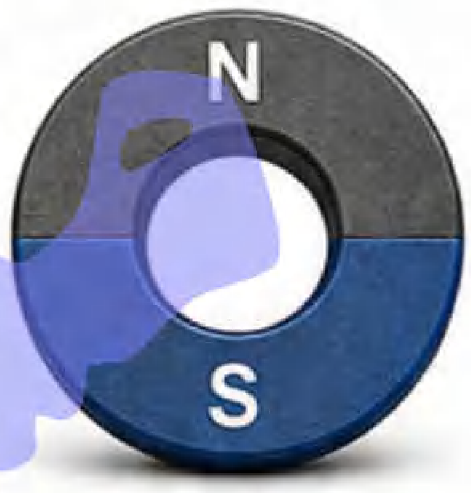
Bar Magnet



Horseshoe Magnet



Magnetic Needle



Ring Magnet

✓ MAGNETIC MATERIALS

These materials are attracted to a magnet.

Iron

Nickel

Cobalt

Wrought Iron

✗ NON-MAGNETIC MATERIALS

These materials are not attracted to a magnet.

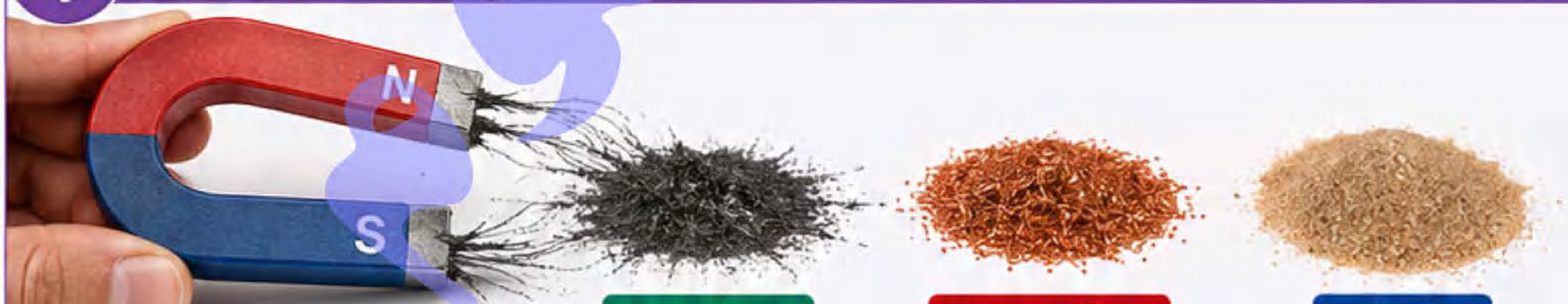
Silver

Copper

Aluminium

Gold

LET'S SEE IT IN ACTION!



Iron Filings | Copper Filings | Sand

A magnet attracts iron filings only.

KEY TAKEAWAY – REMEMBER!

Magnets come in **different shapes** to suit different uses.

Magnets attract only **certain materials**, not all.

LESSON 3

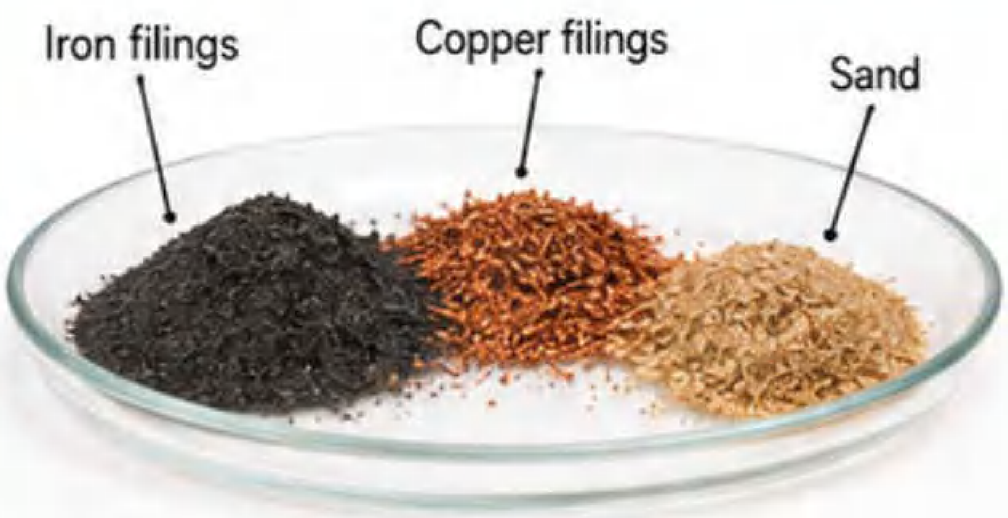
Magnetic Forces

Magnetic Separation & Magnetic Brush

A Magnetic Separation

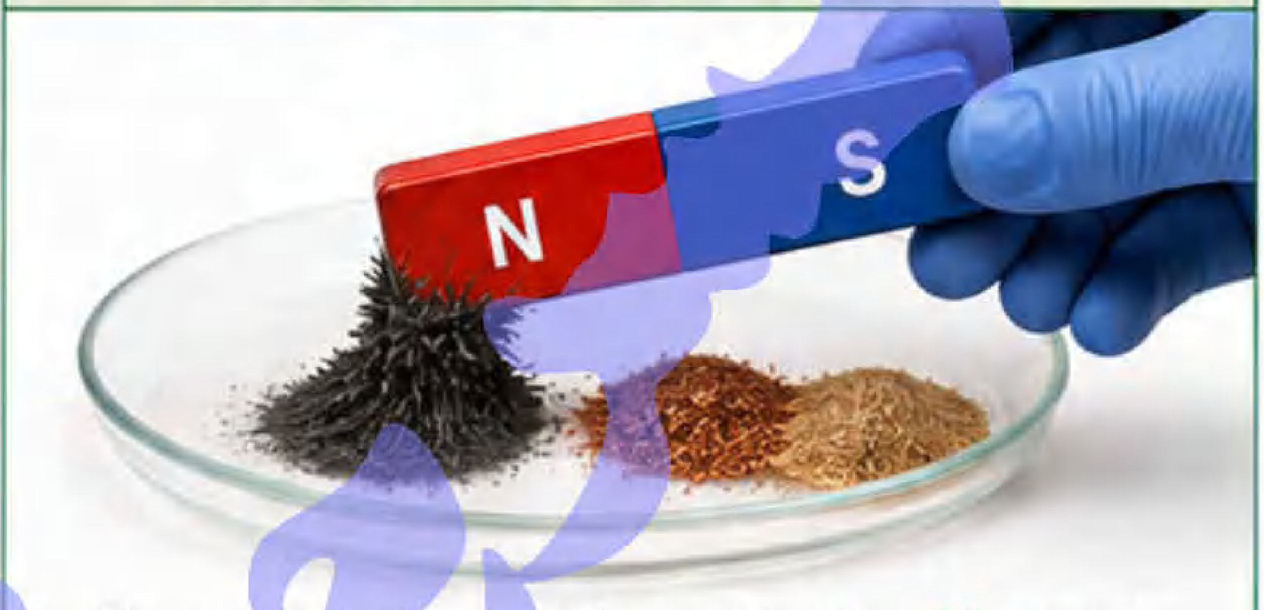
- A magnet can separate magnetic materials from a mixture.

BEFORE: Mixture



Mixture of iron filings, copper filings, and sand.

AFTER: Magnet Near the Mixture



The magnet attracts and separates **iron filings** only.

B Magnetic Brush

A magnetic brush is a tool that uses iron filings to reveal unclear fingerprints.

1. Bring the magnetic brush near iron filings.

The iron filings stick to the brush.

2. Pass the brush over a surface with unclear fingerprints.

The iron filings are deposited onto the surface.

3. Some iron filings remain along the fingerprint traces.

Fingerprints become clearer and easier to see.

KEY TAKEAWAY – REMEMBER!

Magnets can help **separate** magnetic materials and can be used in **forensic** investigations.

Separate magnetic materials

Reveal fingerprints

Support investigations

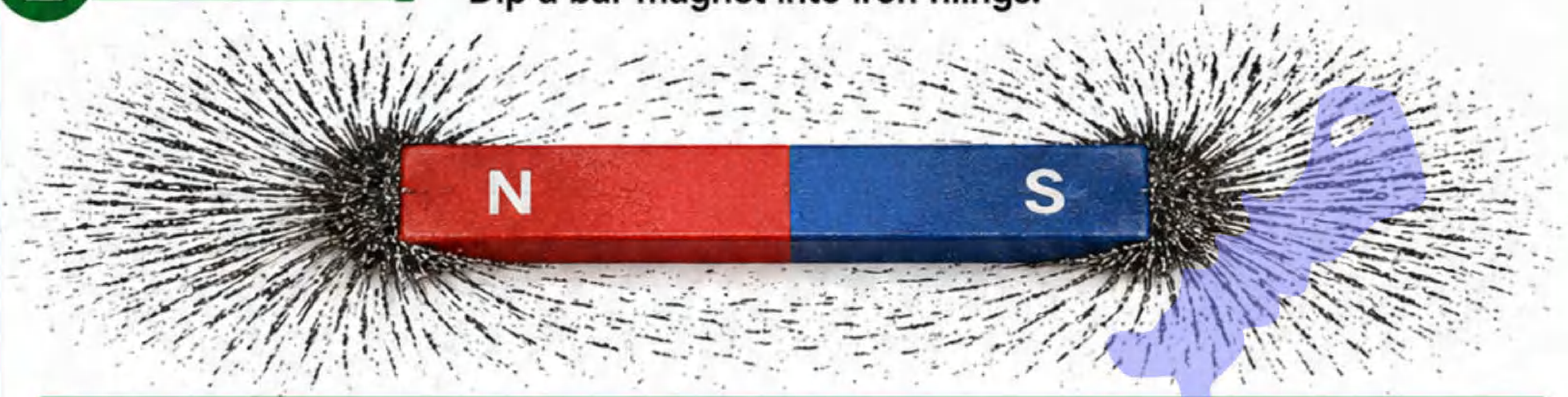
LESSON 4

Magnetic Forces

Strength of a Magnet at Its Poles

EXPERIMENT

Dip a bar magnet into iron filings.



The iron filings are **denser** at both ends (poles) and **sparse** near the middle.

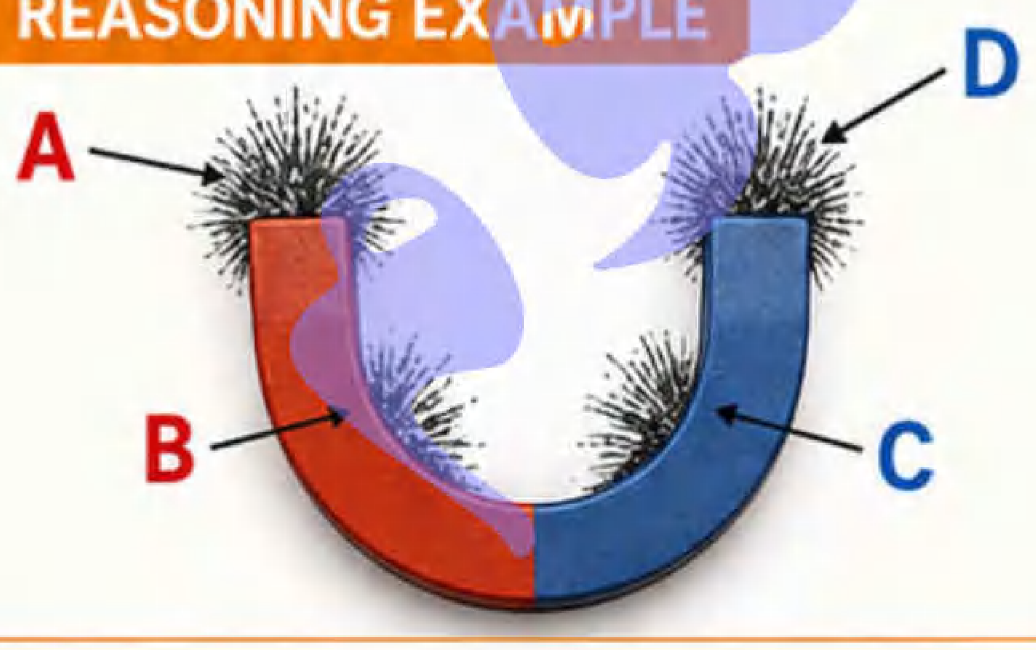
DEFINITION

Magnetic Pole: the region of a magnet where the attracting force is greatest.

CONCLUSION

Magnetic force is greatest at the **poles** and **decreases** toward the middle of the magnet.

REASONING EXAMPLE



- Iron filings are **densest at** **A** and **D**. These are the **poles**.
- Iron filings are **sparse** at **B** and **C**. These are near the middle.
- Therefore, magnetic force is greatest at **A** and **D** (**poles**).

KEY TAKEAWAYS – REMEMBER!

- Magnetic force is **strongest** at the **poles**.
- It becomes **weaker** as you move toward the middle.
- Poles are the **most powerful** parts of a magnet.

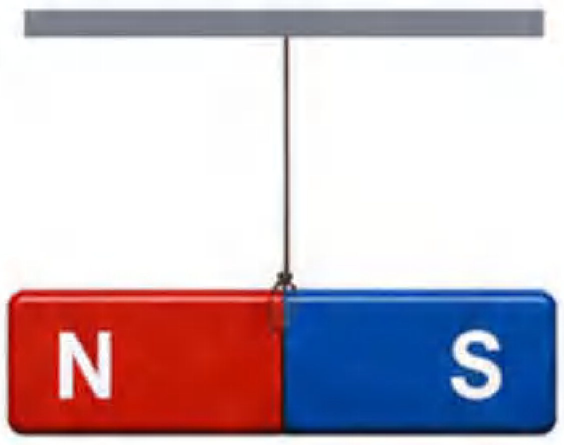
LESSON 5

A Freely Suspended Magnet

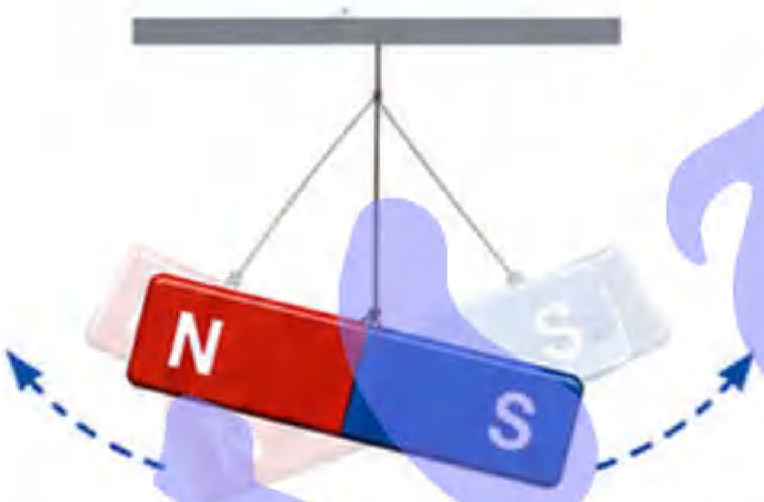
A freely suspended magnet comes to rest in a fixed direction.

EXPERIMENT: What happens?

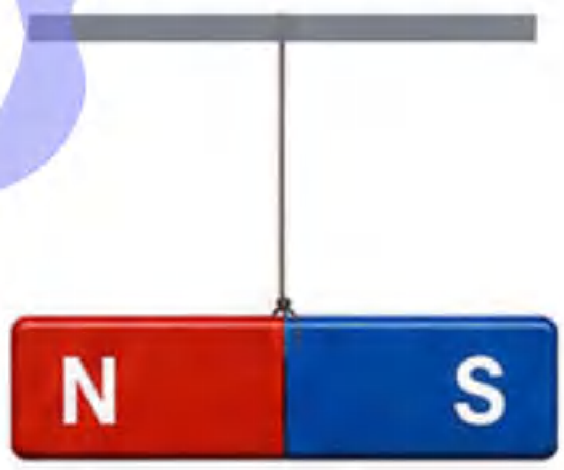
① Suspend a bar magnet from its middle using a silk thread.



② Leave the magnet free to move.



③ After a short time, it comes to rest pointing in a fixed direction.



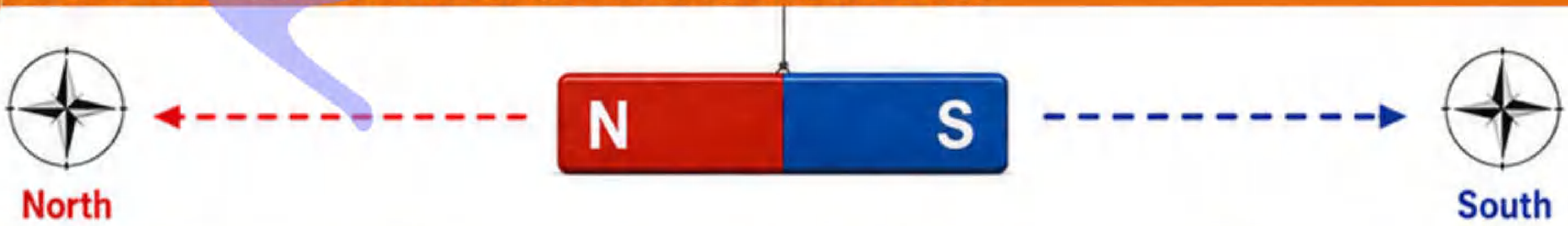
OBSERVATION

A freely suspended magnet always takes a nearly fixed North-South direction.

CONCLUSION

This happens because the **Earth affects** the magnet and makes it settle in that direction.

DIRECTION SHOWN BY A FREELY SUSPENDED MAGNET



KEY TAKEAWAY – REMEMBER!

A freely suspended magnet always settles in a nearly fixed **North-South** direction.

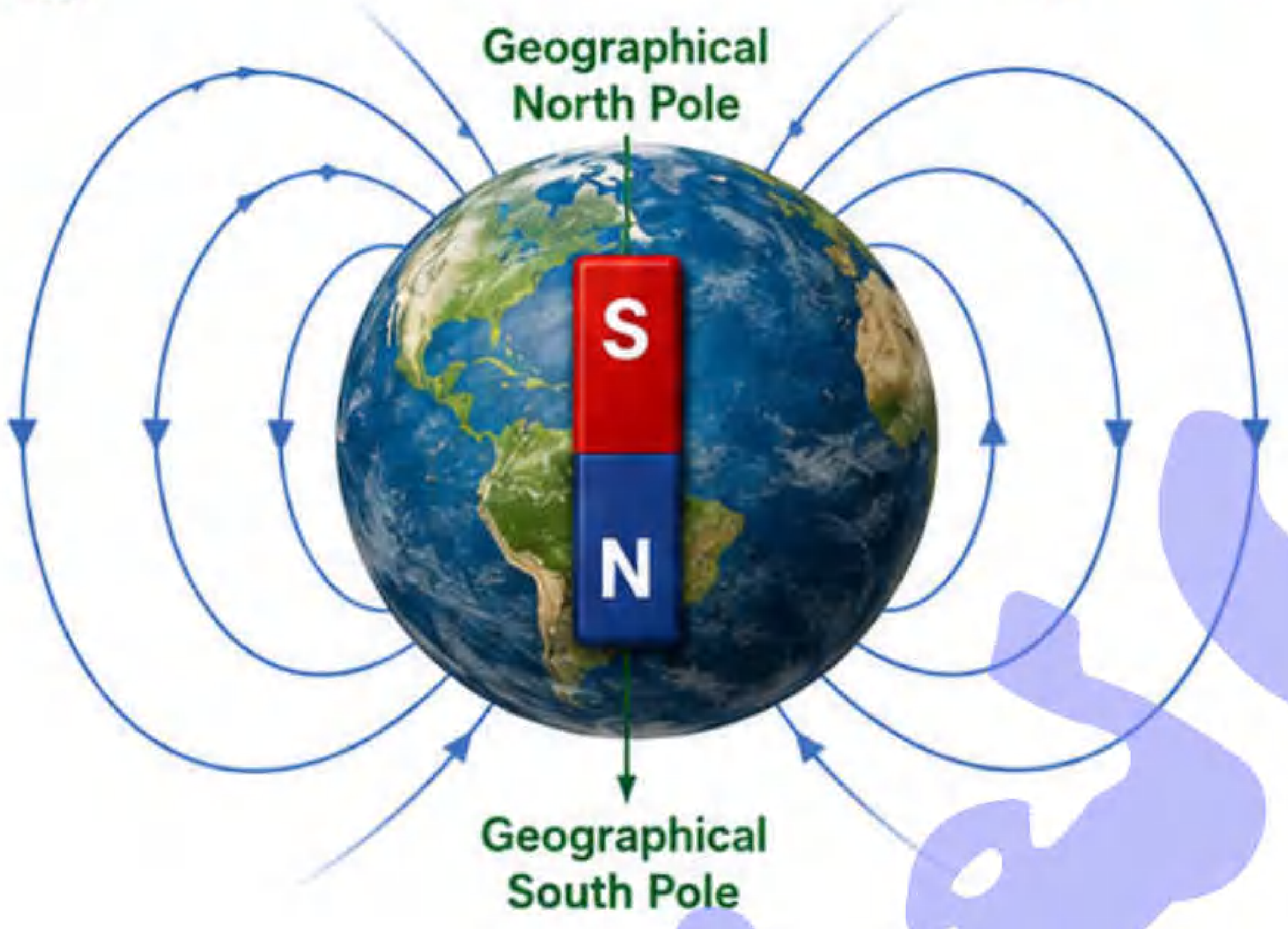
LESSON 6

Magnetic Forces

Earth as a Giant Magnet & the Compass

The Earth behaves like a giant magnet. This is why compasses can find the geographical directions.

A Earth as a Giant Magnet



- The **north pole** of a freely suspended magnet points approximately toward the **geographical North**, which corresponds to the Earth's **magnetic south pole**.
- The **south pole** of the magnet points approximately toward the **geographical South**, which corresponds to the Earth's **magnetic north pole**.

B Compass

N
NE
E
SE
S
SW
W
NW

A compass is a device used to determine the main geographical directions. It contains a magnetic needle free to move.

NOTE

The needle is free to rotate inside the compass case.

KEY TAKEAWAY – REMEMBER!

Earth acts like a bar magnet with its own magnetic poles.

A compass uses this magnetic effect to show directions.

It helps us find the North, South, East, and West anywhere on Earth.

LESSON 7

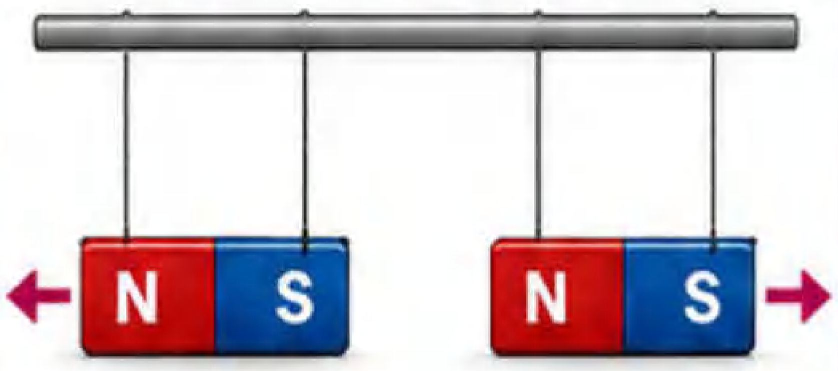
Magnetic Forces

Law of Attraction and Repulsion

Magnets interact through their poles.
The direction of the force depends on which poles face each other.

CASE 1

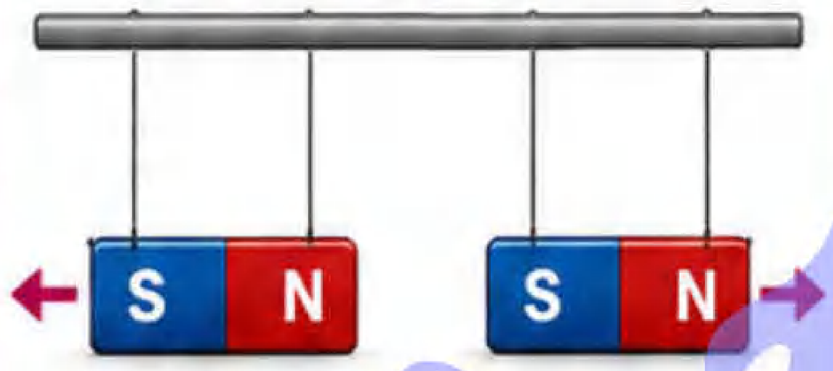
North faces North



REPULSION
Like poles repel.

CASE 2

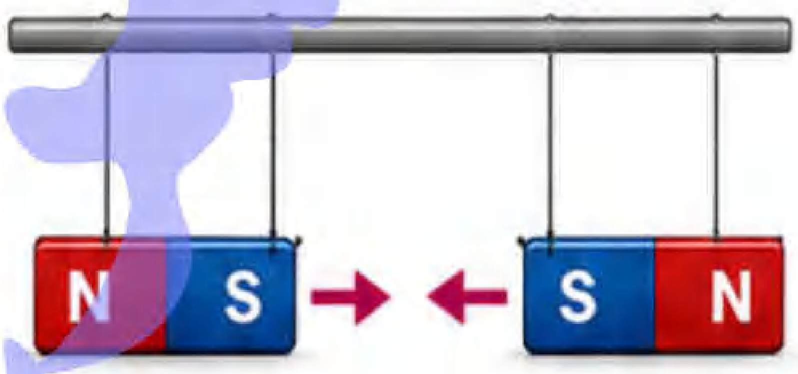
South faces South



REPULSION
Like poles repel.

CASE 3

North faces South



ATTRACTION
Unlike poles attract.

IMPORTANT RULE

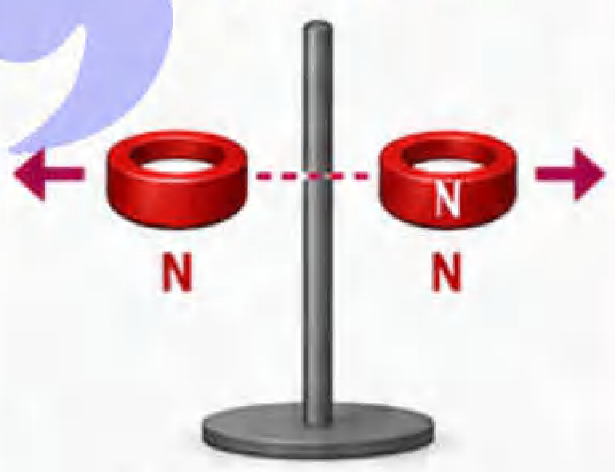
Like poles repel. Unlike poles attract.

APPLICATION EXAMPLE

Ring Magnets on a Stand

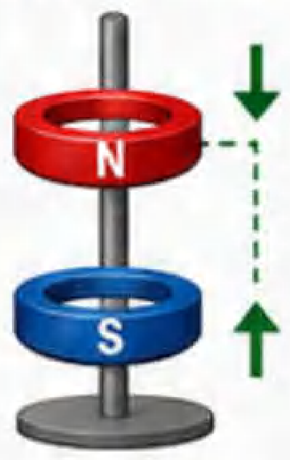
Ring magnets can move up or stay apart depending on the poles that face each other.

Like poles (Repel)



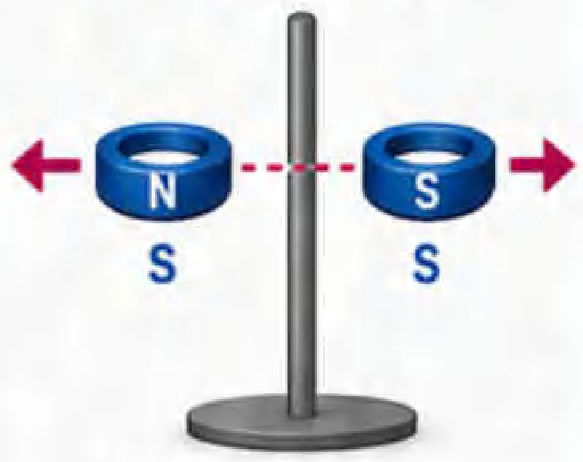
Rings push away and stay apart.

Unlike poles (Attract)



Rings pull together and stick.

Like poles (Repel)



Rings push away and stay apart.

KEY TAKEAWAY – REMEMBER!

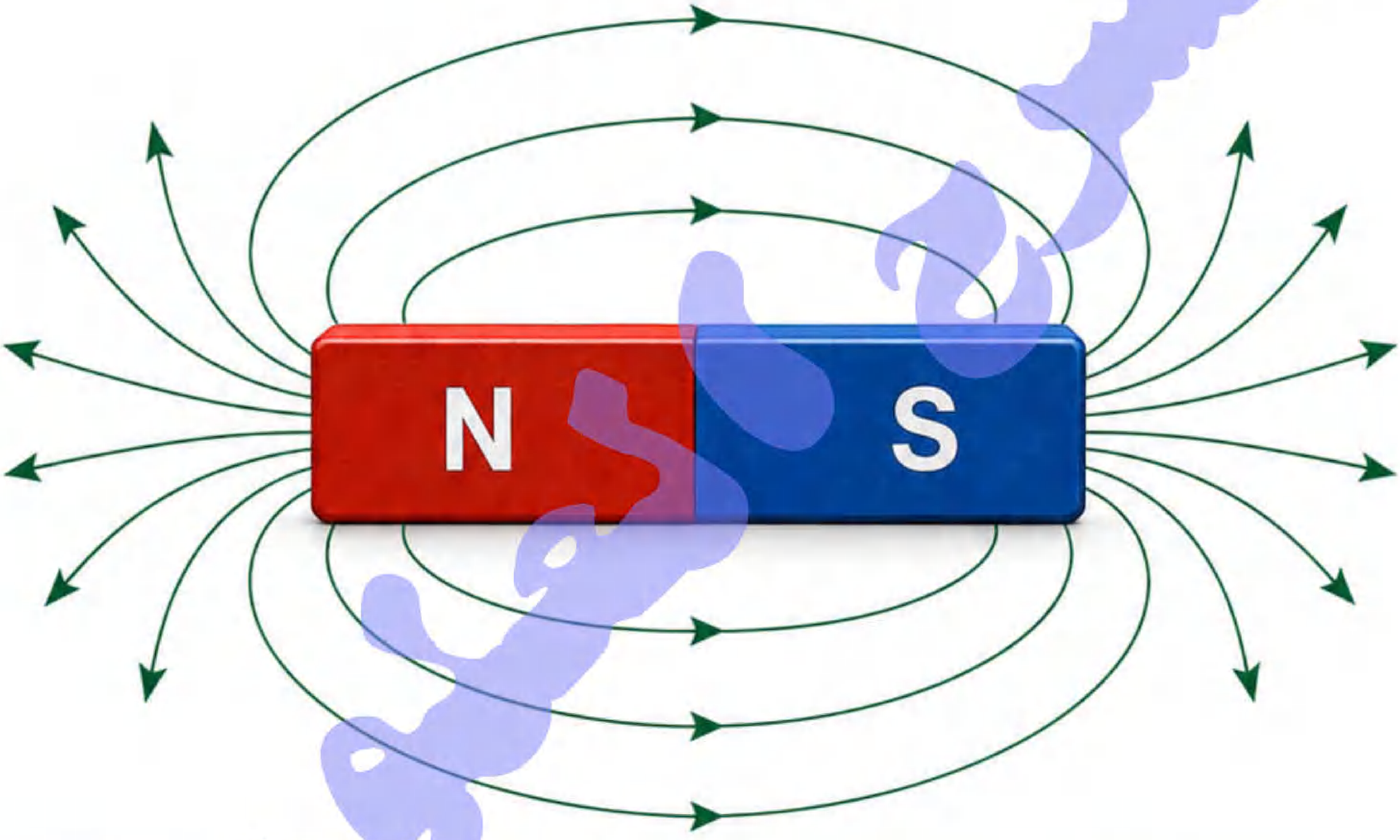
N	North repels North. Like poles repel.
S	South repels South. Like poles repel.
N S	North attracts South. Unlike poles attract.

LESSON 8

The Magnetic Field

Magnetic Field: the region around a magnet where its magnetic force can be observed.

Magnetic Field Lines: imaginary lines that represent the magnetic field and its force.



A magnet is surrounded by a magnetic field that **extends through space** around it.

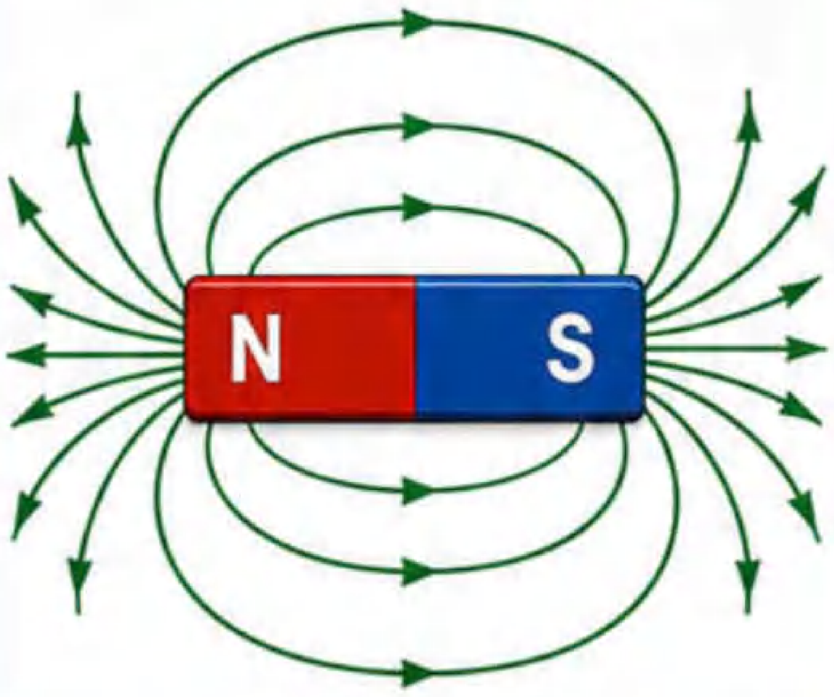
KEY TAKEAWAY – REMEMBER!

The magnetic field is the **invisible area** around a magnet where magnetic forces can act. Magnetic field lines help us visualize the field and show the **direction** of its force.

LESSON 9 Magnetic Field-Line Patterns

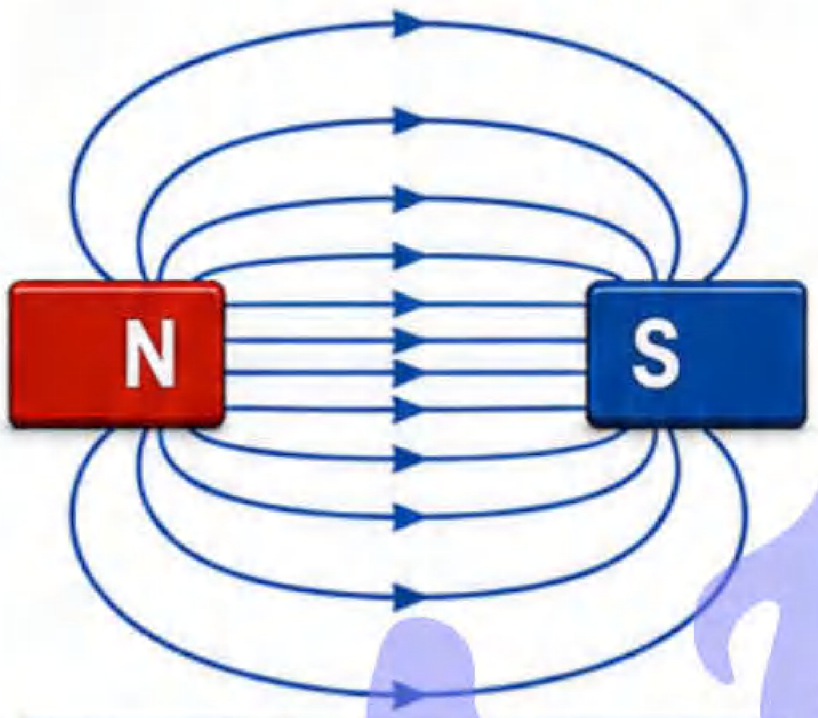
Magnetic field lines show the **direction and shape** of a magnet's magnetic field.

1 Field lines around one bar magnet



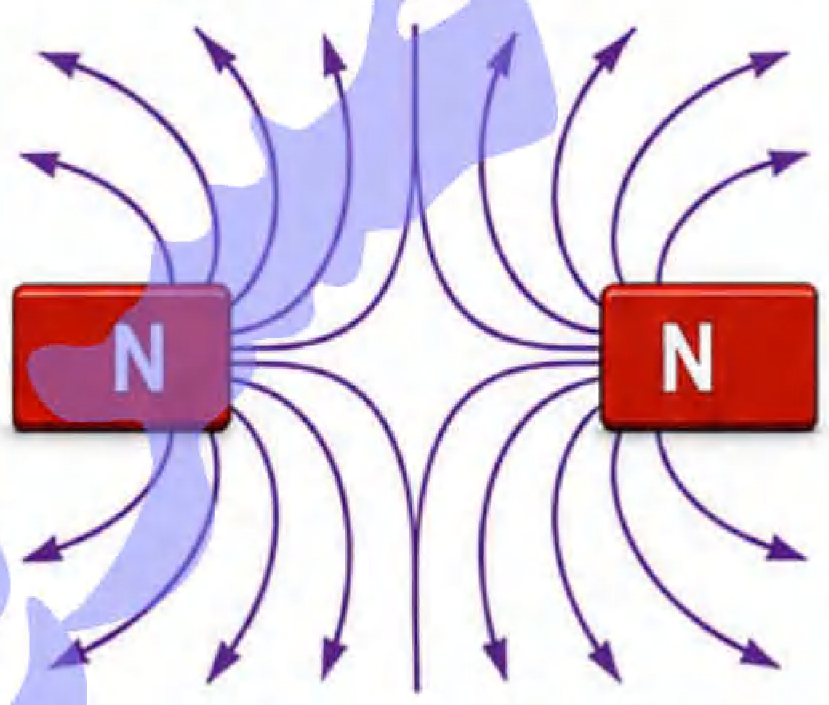
Outside the magnet, field lines leave the **north pole** and enter the **south pole**.

2 Field lines between two unlike poles



Field lines go from the **north pole (N)** to the **south pole (S)**.

3 Field lines between two like poles

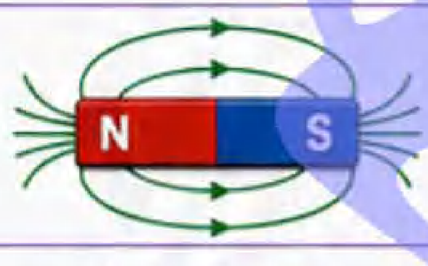


Field lines do not connect. They repel and curve away from each other.

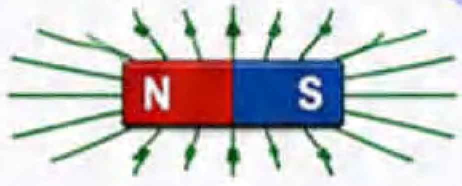
PROPERTIES OF MAGNETIC FIELD LINES

1. **Magnetic field lines are imaginary.** We use them to represent the magnetic field.

2. **Magnetic field lines do not intersect.** At any point, the field has only one direction.



3. **Outside the magnet,** field lines start at the **north pole** and end at the **south pole**.



4. **Field lines are crowded** near the poles and **spread out** farther away.

KEY TAKEAWAY – REMEMBER!

Where field lines are *denser*, the magnetic field is **stronger**.
That is why the field is **strongest** near the **poles**.

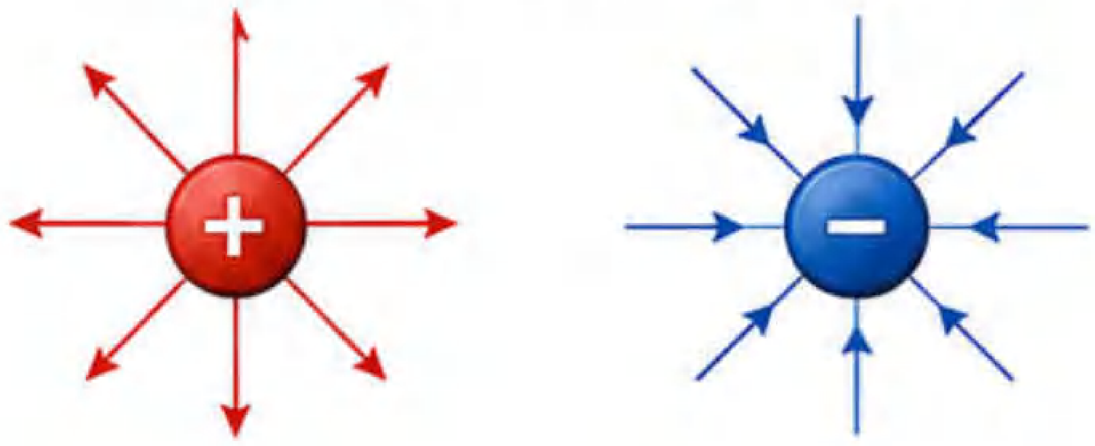
LESSON 10

Electric vs Magnetic Fields & Final Review

1 What Are They?

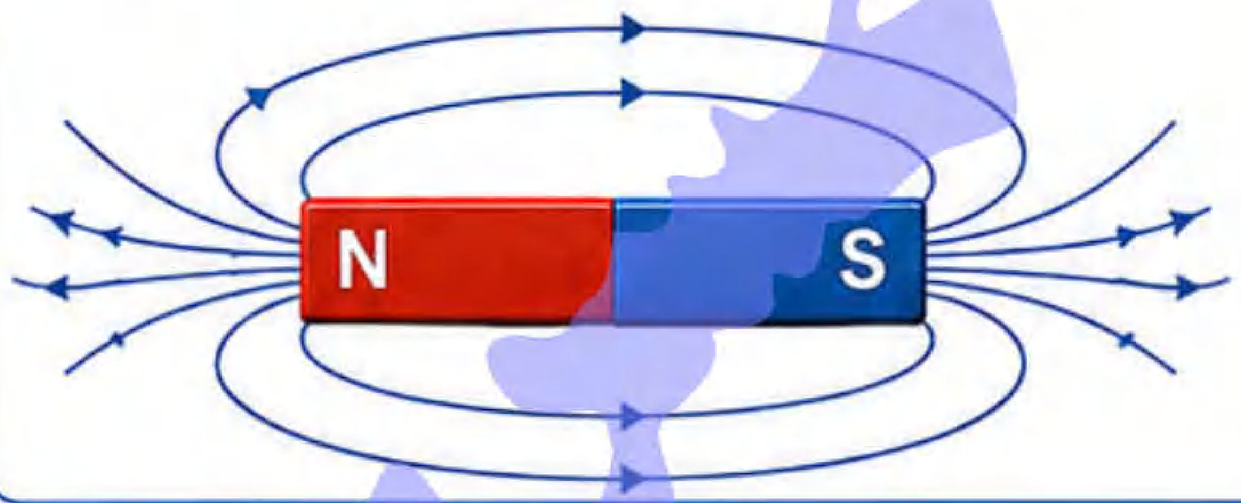
Electric Field

The region around an electric charge where its effect appears.



Magnetic Field

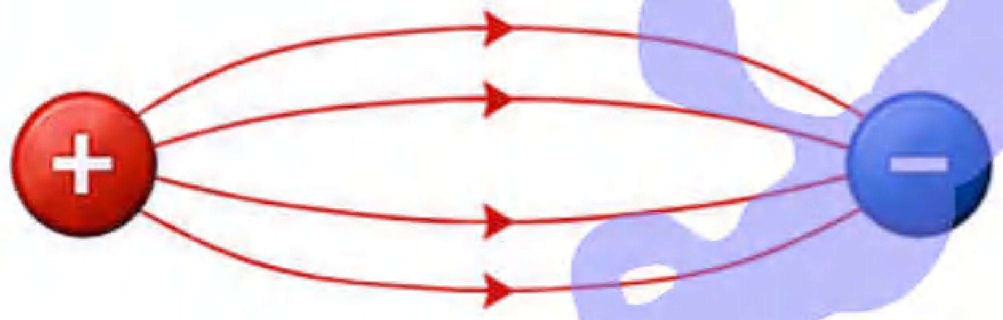
The region around a magnet where its magnetic effect appears.



2 About Field Lines

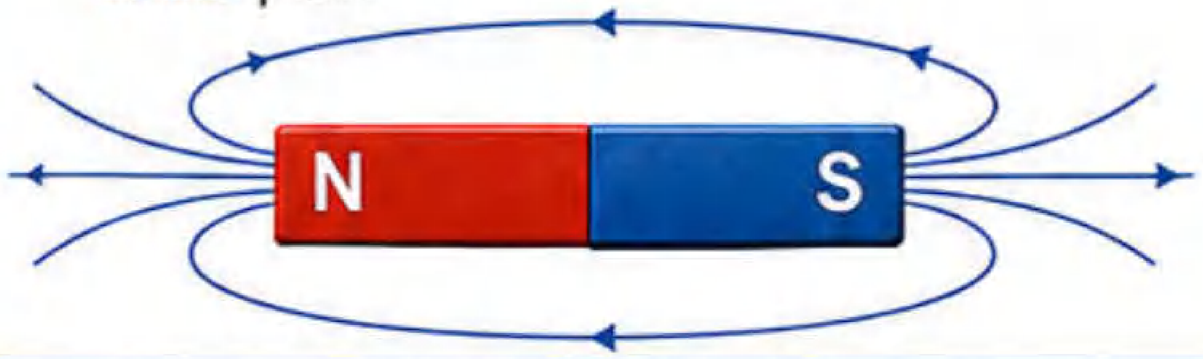
Electric Field Lines

- Electric field lines are imaginary.
- They do not intersect.
- They start at the **positive** charge and end at the **negative** charge.



Magnetic Field Lines

- Magnetic field lines are imaginary.
- They do not intersect.
- Outside the magnet, they start at the **north** pole and end at the **south** pole.



3 Final Review – Key Points

1. **Types of magnets:** Magnets are of two types – natural (lodestone) and artificial (man-made).
2. **Magnetic materials:** Magnets attract some metallic materials such as iron, nickel, cobalt and steel.
3. **Poles:** Every magnet has two poles – North (N) and South (S). Like poles repel; unlike poles attract.
4. **Direction:** A freely suspended magnet always aligns in the north–south direction.
5. **Forces:** Between two magnets, the force may be attraction or repulsion depending on the poles. Between a magnet and a magnetic material, the force is always attraction.
6. **Magnetic field lines:** They are imaginary, do not intersect, and outside the magnet go from the north pole to the south pole.

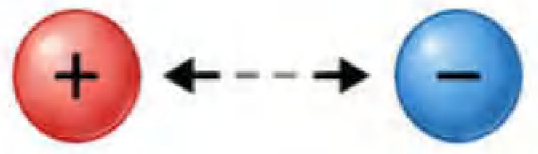
REMEMBER! Between two magnets the force may be attraction or repulsion. Between a magnet and a magnetic material the force is attraction.

Types of Forces & Gravitational Force

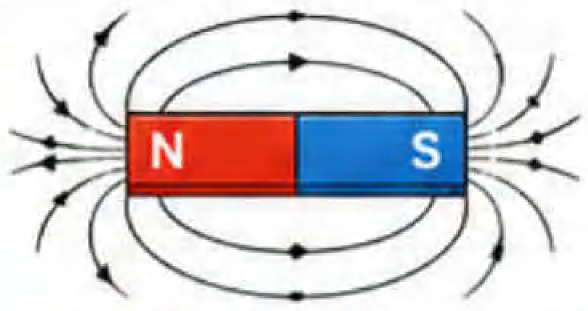
Forces can be classified into **two main types**: **field forces** and **contact forces**.

A Field Forces

Forces that act without direct contact.

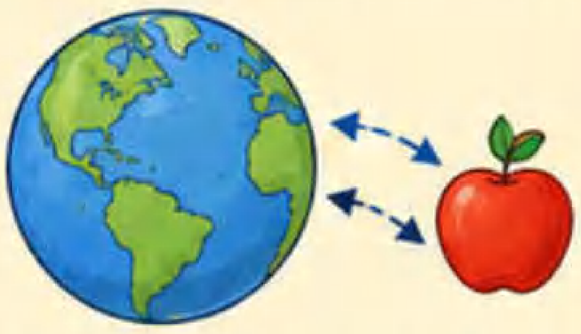
1 

Electrostatic Force

2 

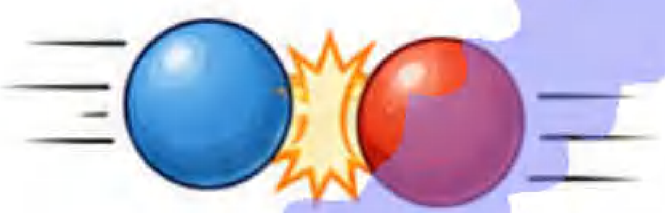
Magnetic Force

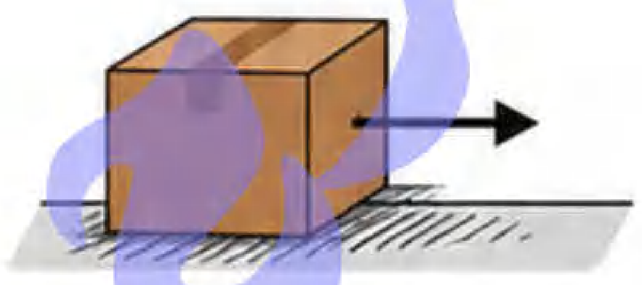
FOCUS OF THIS LESSON

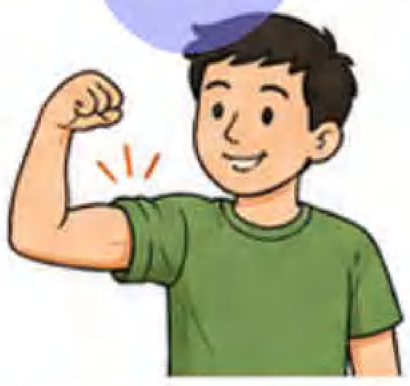
3 
Gravitational Force

B Contact Forces

Forces that act only when objects touch.

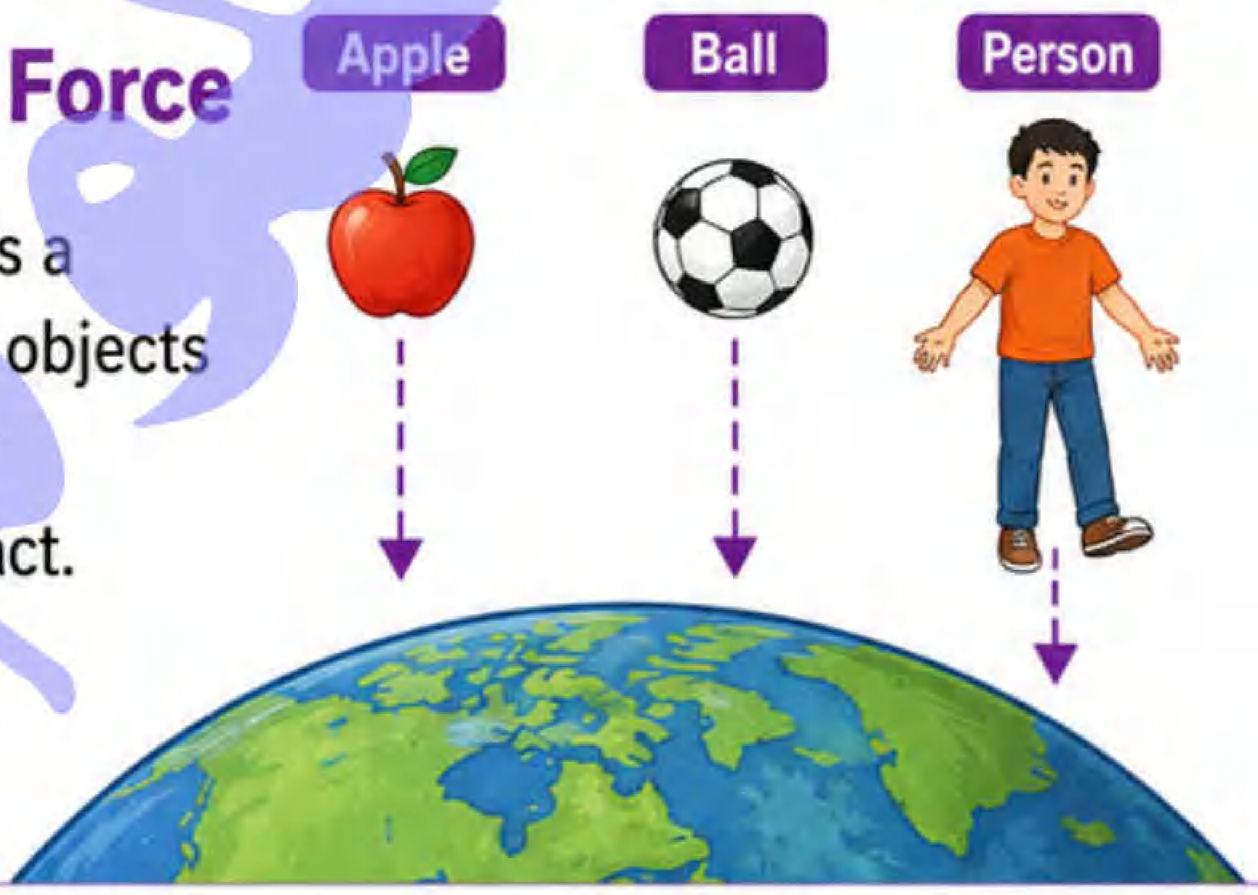
1 
Collision Force

2 
Friction Force

3 
Muscular Force

Gravitational Force

Gravitational force is a **field force**. It pulls objects toward one another without direct contact.



Near Earth's surface, objects **fall toward the center of the Earth.**

KEY TAKEAWAY

1. Gravitational force is one of the **field forces**.
2. Field forces act **without contact**.
3. Contact forces need **touching**.

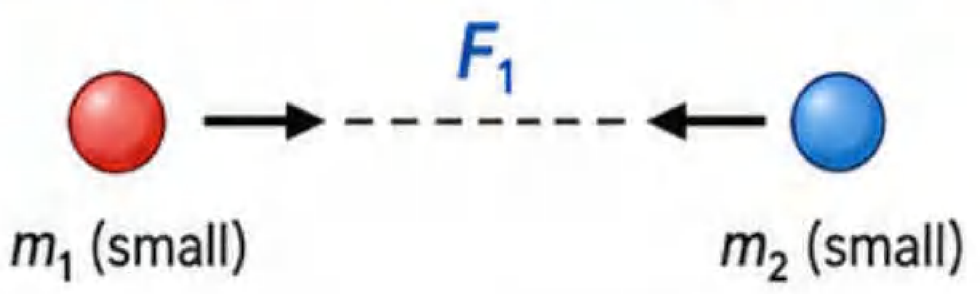
What Controls Gravitational Attraction?

Gravitational attraction exists between **any two bodies that have mass**.

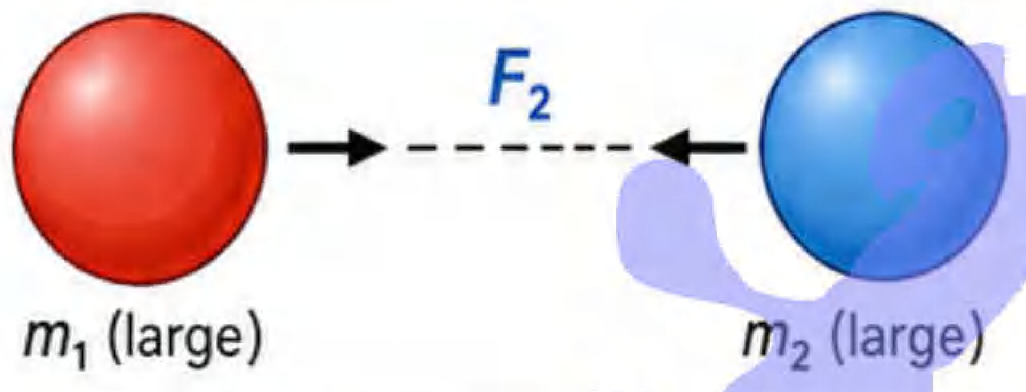
1 Masses of the Two Bodies

Larger masses give **stronger** gravitational **attraction**.

Small Masses (Weaker Attraction)



Large Masses (Stronger Attraction)

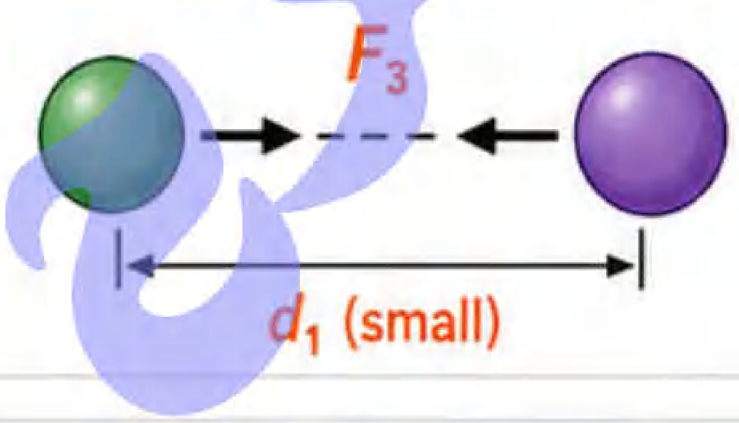


F_2 is much **greater** than F_1.

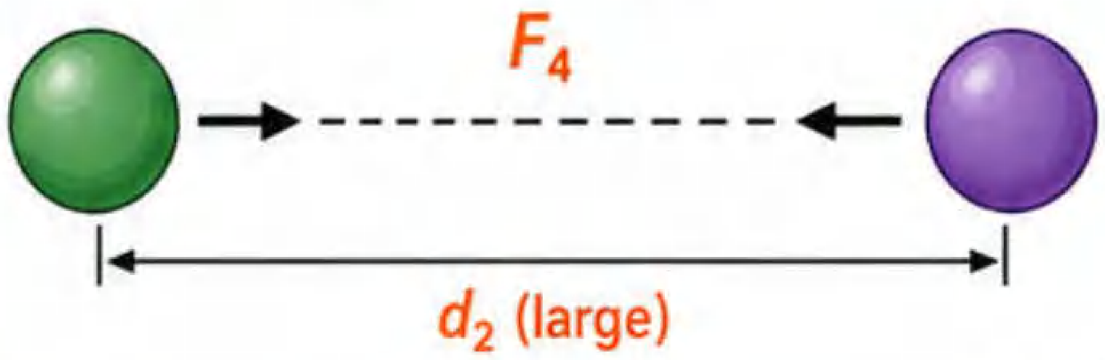
2 Distance Between Their Centers

Greater distance gives **weaker** gravitational **attraction**.

Near (Stronger Attraction)



Far (Weaker Attraction)



F_4 is much **less** than F_3.

Relationship Summary

- Gravitational force **increases** as the **masses** of the two bodies increase.
- Gravitational force **decreases** as the **distance** between their centers increases.

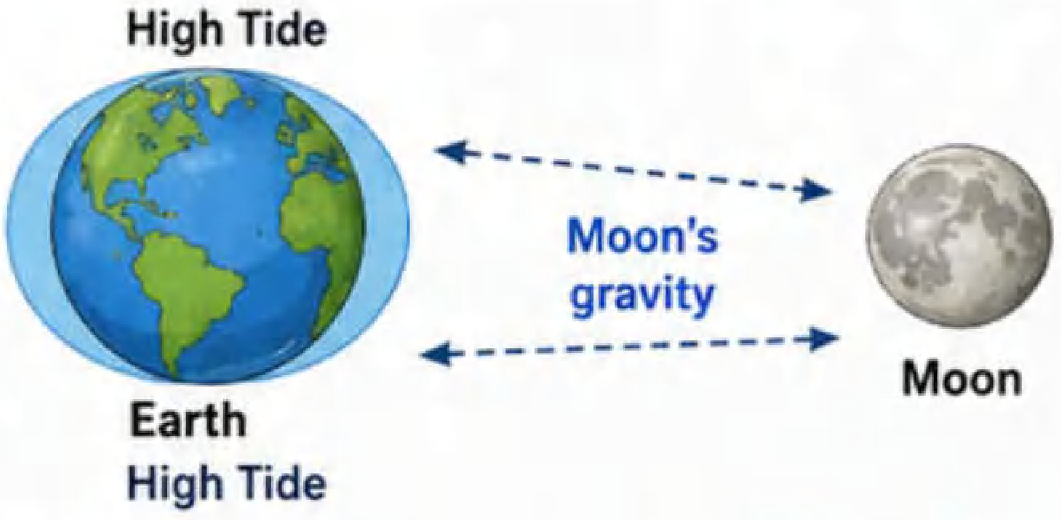
KEY TAKEAWAY

1. Any two bodies with **mass** attract each other.
2. More mass means **stronger** gravitational attraction.
3. More distance means **weaker** gravitational attraction.

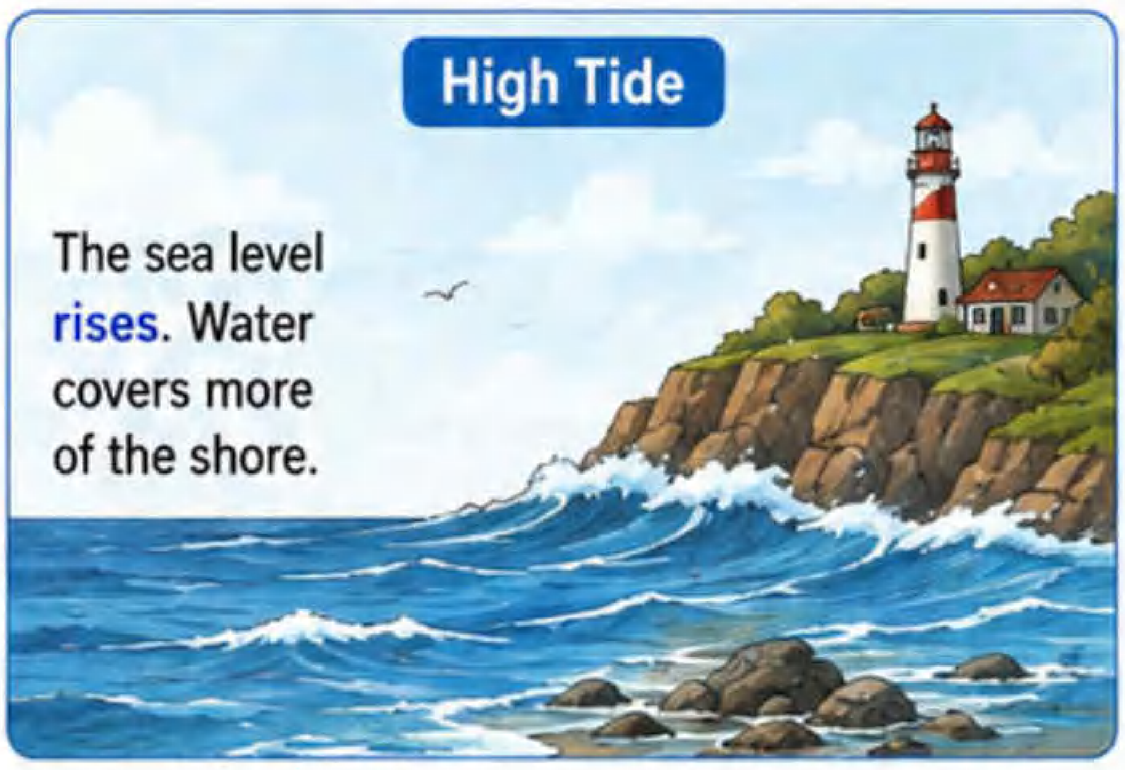
Tides and Black Holes

A Tides

The Moon's **gravitational attraction** pulls on Earth's oceans, causing changes in sea level. These regular rises and falls of sea level are called **tides**.



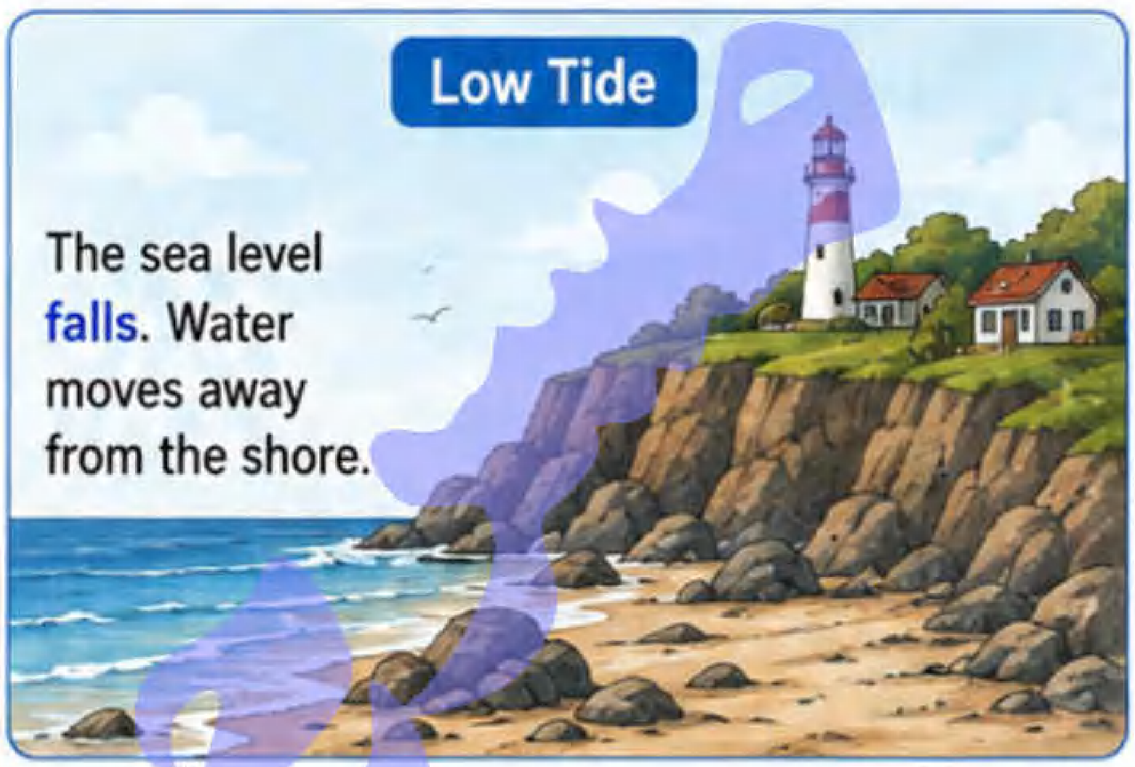
High Tide



The sea level **rises**. Water covers more of the shore.

Tides happen periodically.

Low Tide



The sea level **falls**. Water moves away from the shore.

Real-Life Importance of Tides

Help in **navigation** for ships.

Used to generate **renewable energy**.

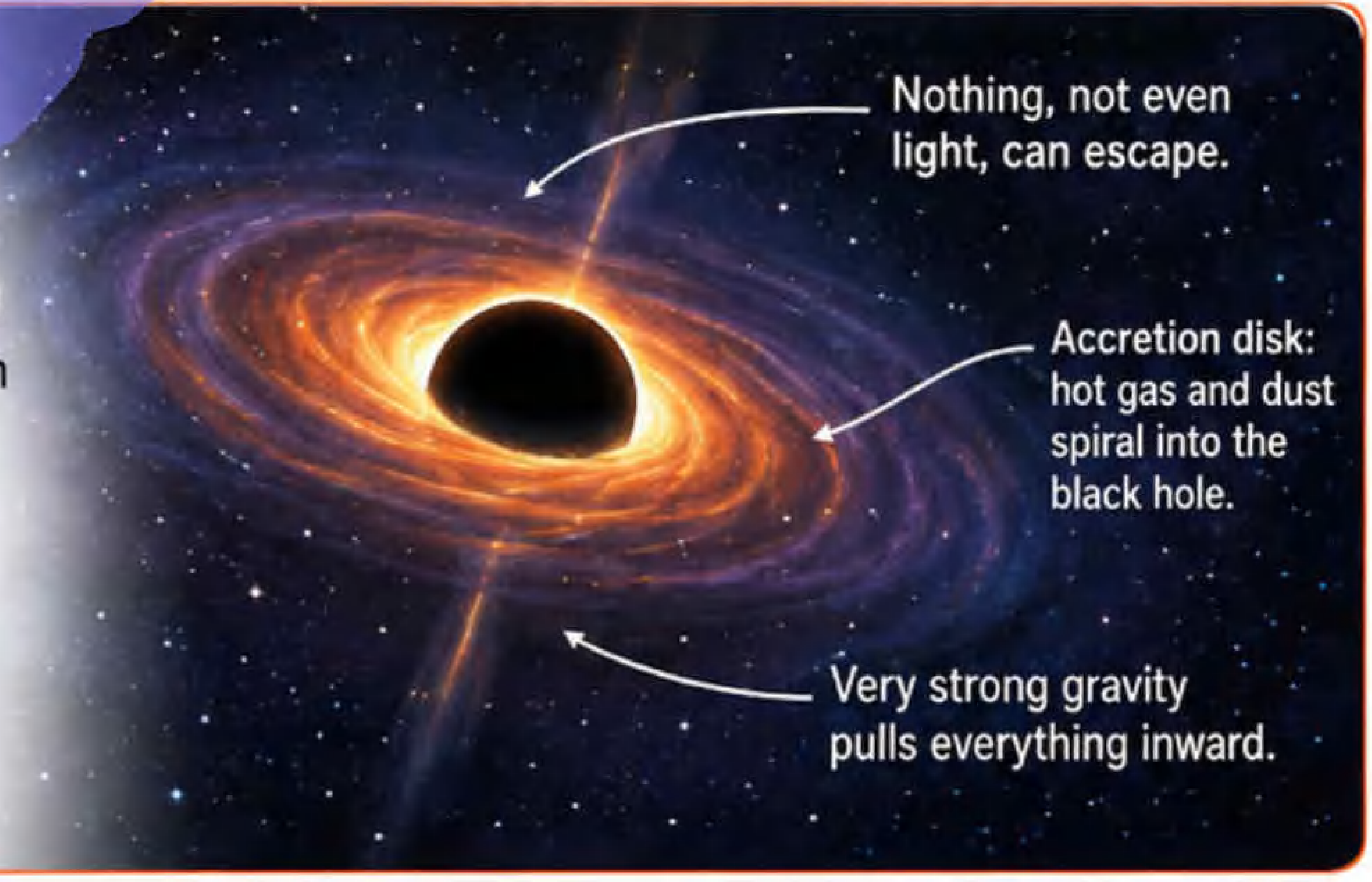
Support coastal **ecosystems** and marine life.

Affect beach activities and **coastal communities**.

B Black Holes

A black hole is a region in space where gravity is **extremely strong**. It is created when a very massive star collapses in on itself. The gravity is so strong that **not even light** can escape.

Did You Know?
Black holes can be millions of times more massive than the Sun!



Nothing, not even light, can escape.

Accretion disk: hot gas and dust spiral into the black hole.

Very strong gravity pulls everything inward.

KEY TAKEAWAY

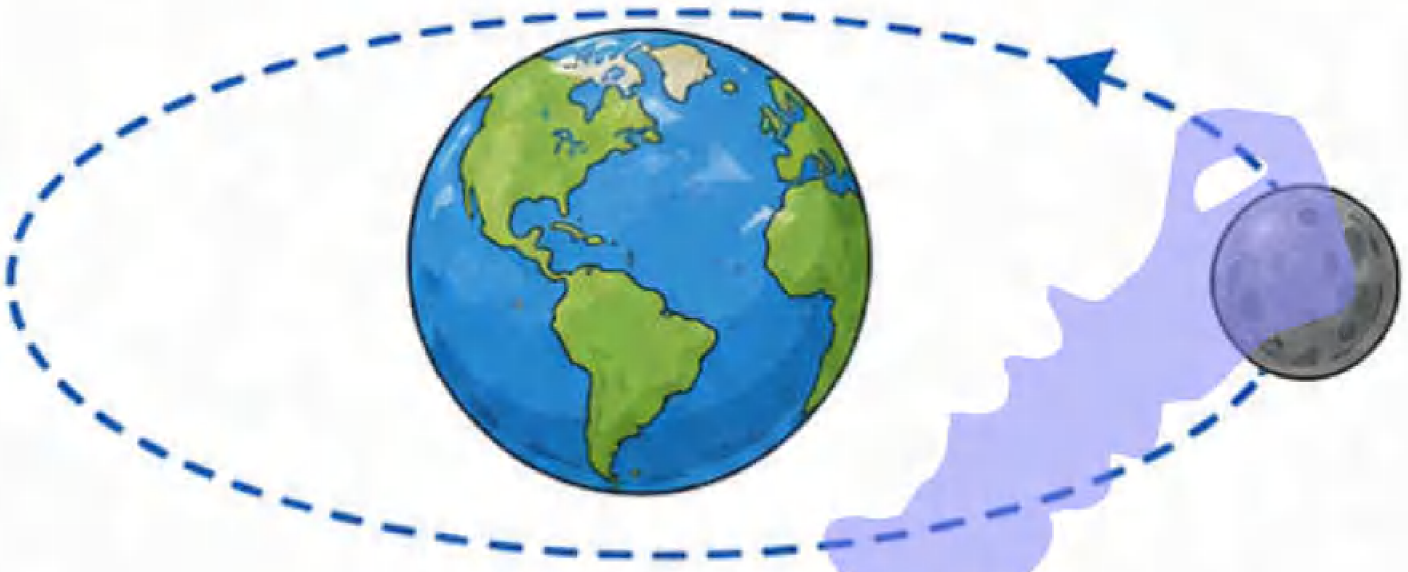
1. Tides are caused by the **Moon's gravity** pulling on Earth's oceans.
2. Tides happen **periodically**—high tide and low tide.
3. Black holes have **extremely strong gravity** that traps everything.

Gravity and Orbital Motion

Orbital motion is the motion of a body in space along a **curved path** around another body due to **gravitational attraction**.

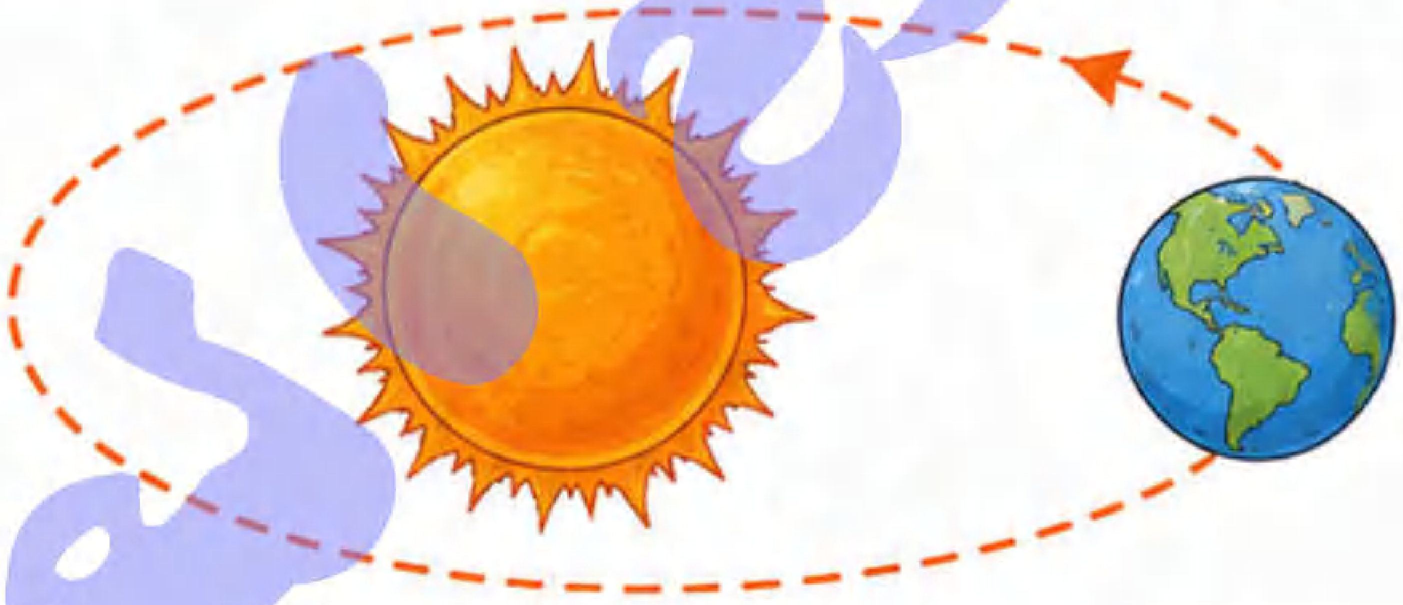
1 The Moon around Earth

The Moon is pulled toward Earth by **gravity**. This keeps it moving in its **orbit** around Earth.



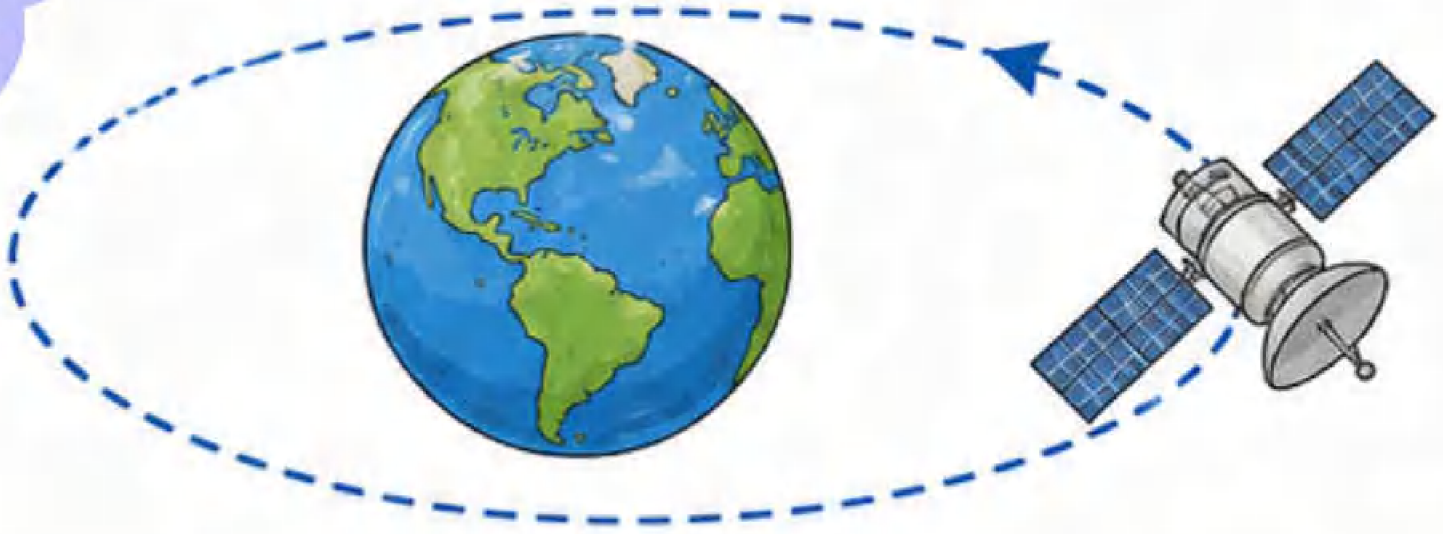
2 The Earth around the Sun

The Sun's **gravity** pulls the Earth toward it. This keeps the Earth moving in its **orbit**.



3 An Artificial Satellite around Earth

A satellite is pulled toward Earth by **gravity**. This keeps it moving along its **orbital path**.



In all these examples, **gravity** provides the pull that keeps objects moving along their **orbital paths**.

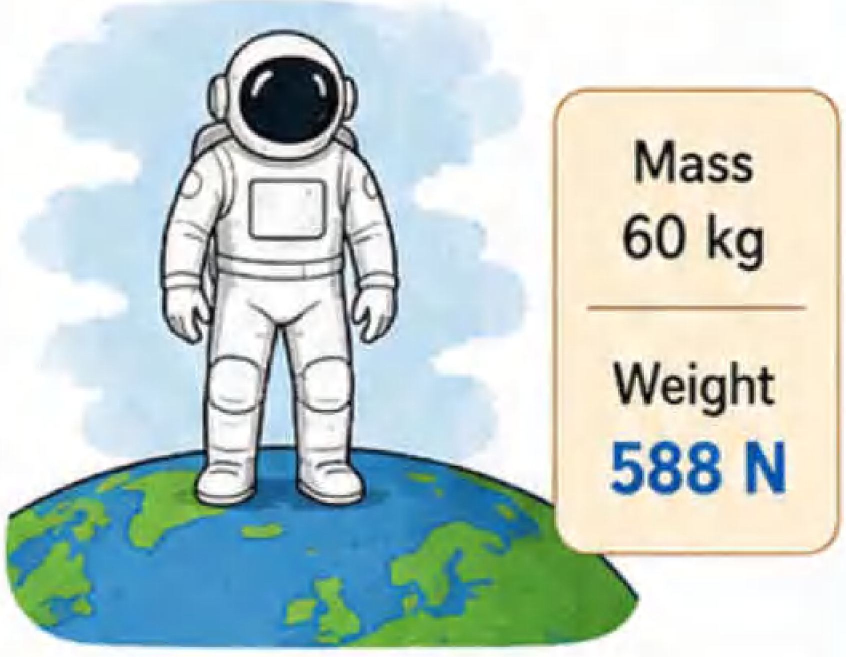
KEY TAKEAWAY

1. Orbital motion is caused by **gravity** acting at a distance.
2. It keeps objects moving along **curved paths**.
3. Without gravity, these objects would move in a **straight line**.

Weight on Earth, Moon & Final Review

Mass stays the **same**, but **weight changes** depending on the **gravitational field strength**.

EARTH



Mass
60 kg

Weight
588 N

Gravitational field strength on Earth (g_e) ≈ 9.8 N/kg

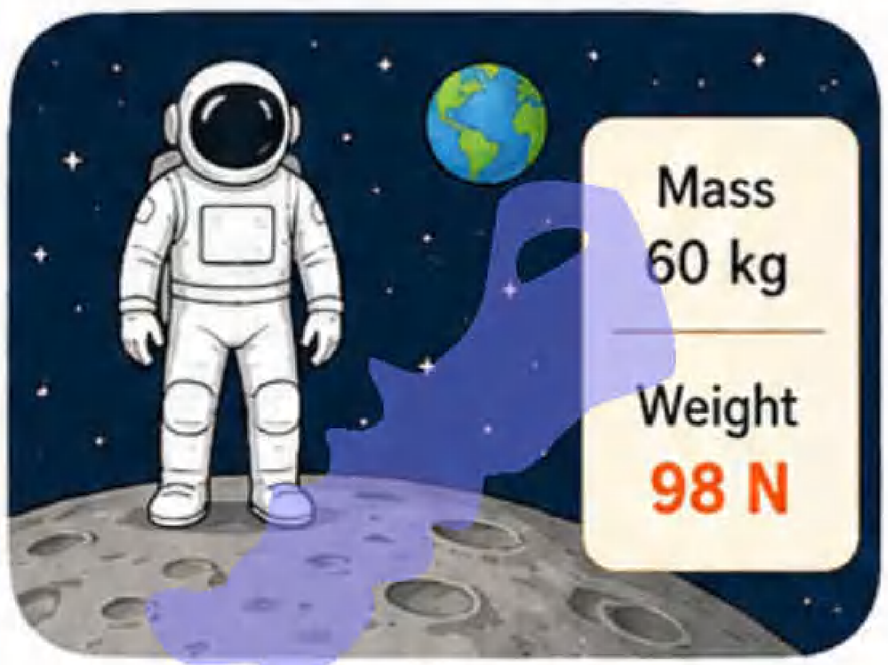
Why is weight different?

The Moon's gravitational field strength is about one sixth of Earth's.

Weight on Moon
$= \frac{1}{6} \times$ Weight on Earth

Weight on Earth
$= 6 \times$ Weight on Moon

MOON



Mass
60 kg

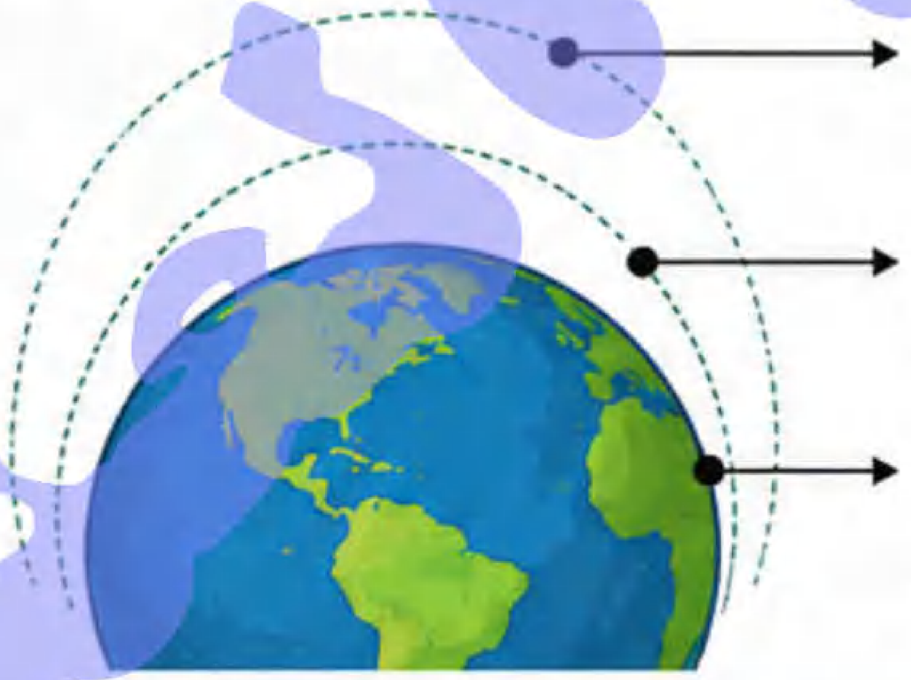
Weight
98 N

Gravitational field strength on Moon (g_m) ≈ 1.6 N/kg
(about 1/6 of Earth's)

Effect of Altitude

As you go higher above Earth's surface, the **distance from Earth's center** increases.

Gravitational field strength ↓
Weight ↓
Things feel "**lighter**".



High altitude (farther away)
Weaker gravity → **Less weight**

Mid altitude
Weaker gravity → **Less weight**

Earth's surface (lowest altitude)
Stronger gravity → **More weight**

FINAL REVIEW

Gravitational Forces

- **Types of Forces**
  - **Field Forces**
    Act without direct contact.
    - Gravitational Force
    - Electrostatic Force
    - Magnetic Force
  - **Contact Forces**
    Act only when objects touch.
    - Friction Force
    - Normal Force
    - Muscular Force
    - Collision Force
- **Gravitational Force**
  - Always attractive
  - Acts between any two masses
  - Strength depends on mass and distance
  - Near Earth's surface → weight = mg

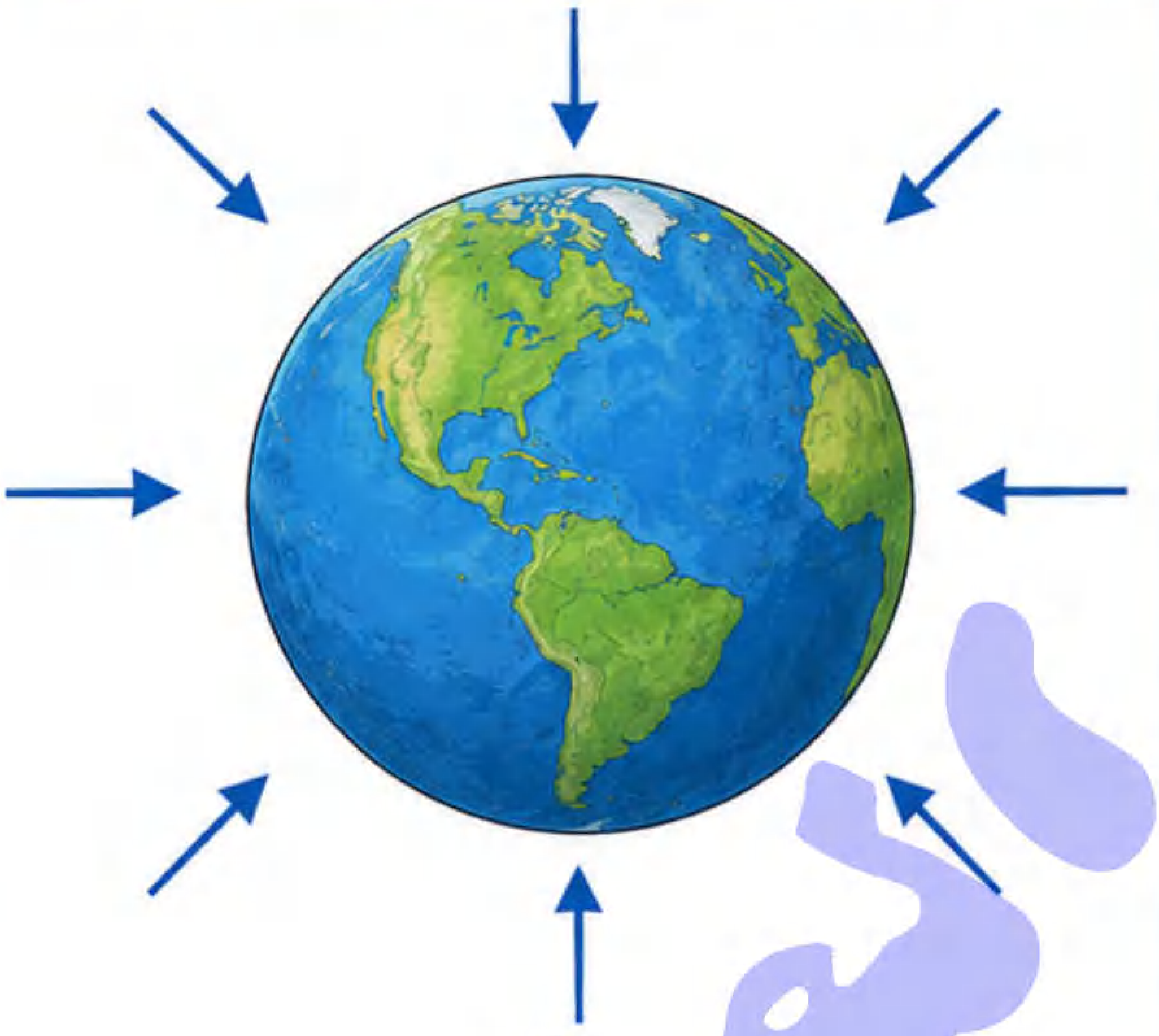
REMEMBER!

- ✓ Mass is the amount of matter in an object (kg). It does not change.
- ✓ Weight is the gravitational force on an object (N). It can change.
- ✓ Moon gravity ≈ 1/6 of Earth's gravity.
- ✓ Higher altitude → weaker gravity → **less weight.**

Earth's Gravitational Field

Earth's gravitational force pulls objects **toward** the **center of the Earth.**

Gravity Pulls Toward the Center



Earth's Gravitational Field

Earth's gravitational field is the **region** around Earth where gravity acts and pulls objects toward the **center of the Earth.**

Gravitational Field Lines

Gravitational field lines are imaginary lines that show the **direction** of gravitational force. Around Earth, these lines point toward the **center of the Earth.**

Examples: Everything Falls Toward Earth

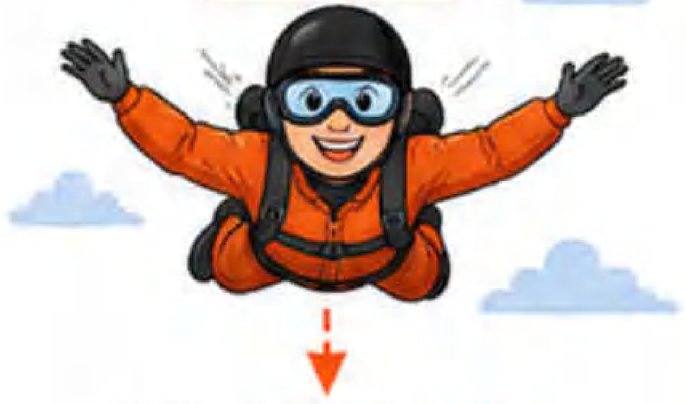
Ball

Pulled **downward** toward Earth.

Apple

Pulled **downward** toward Earth.

Skydiver



Pulled **downward** toward Earth.

KEY TAKEAWAY

1. Gravity pulls objects toward the **center** of the Earth.
2. Earth's gravitational field is the **region** where gravity acts.
3. Field lines show the direction of gravity – **toward the center.**

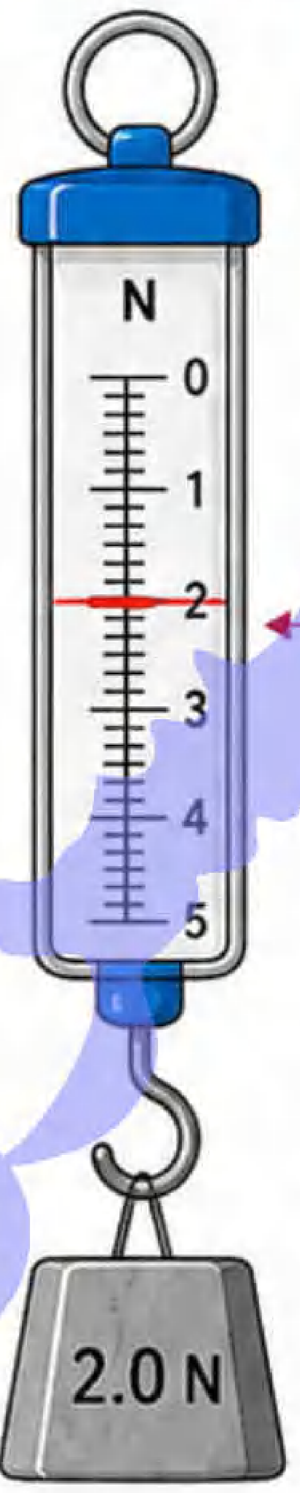
Mass and Weight

Mass is how much matter something has.
Weight is how hard gravity pulls on that mass.

Mass	Weight
Amount of **matter** in a body.	Earth's **gravitational force** acting on a body.
Measured in **kilogram (kg)**.	Measured in **newton (N)**.
Does **not change** with location.	**Changes** when the gravitational field changes.
Measured using a balance or scale.	Measured using a spring balance (Newton meter).

Measuring Weight

We measure weight using a **spring balance** (Newton meter).



This object has a weight of 2.0 newton (N).

Mass–Weight Relationship on Earth

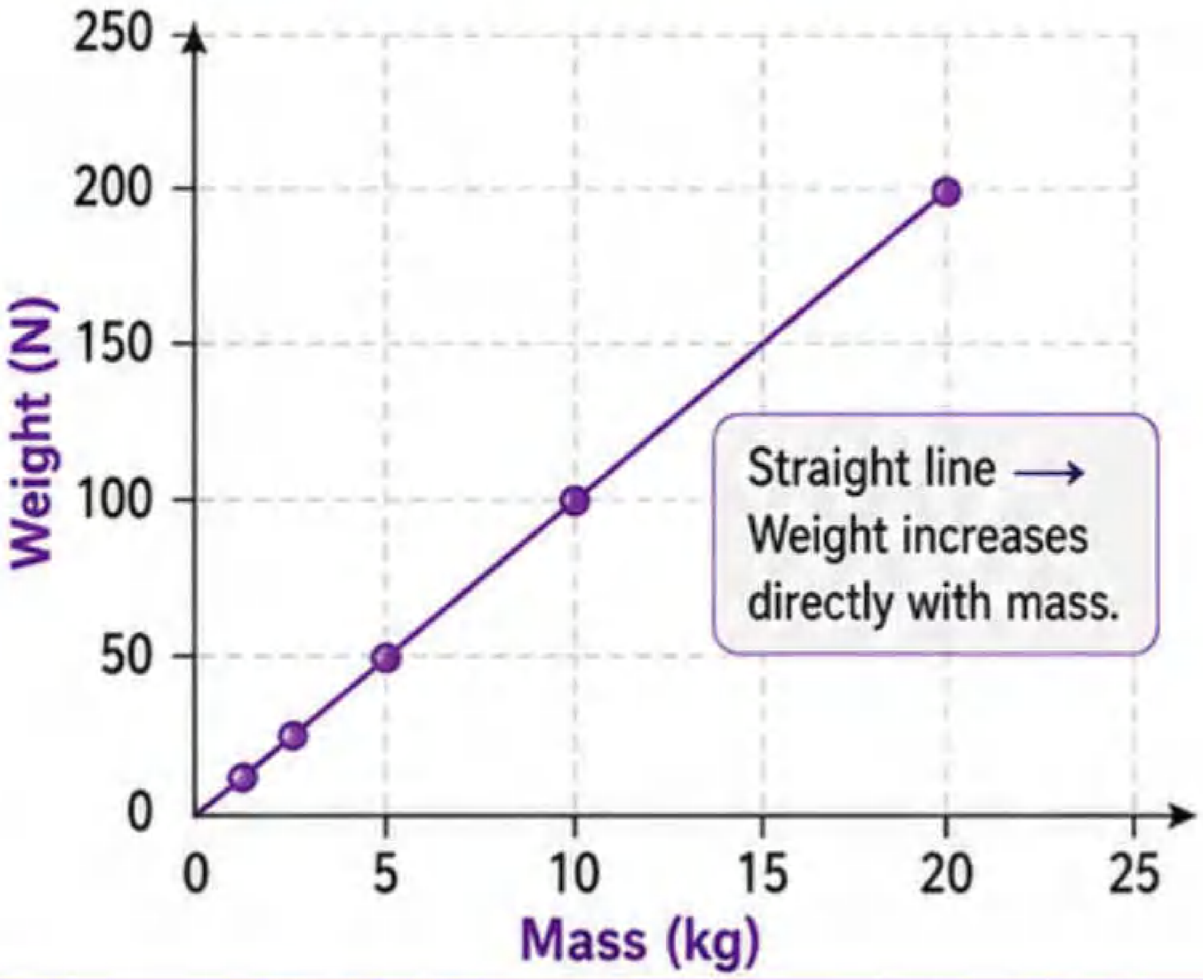
On Earth, weight (W) is directly proportional to mass (m).

The relationship is: $W = m \times g$

where g ≈ 9.8 N/kg (acceleration due to gravity on Earth).

Mass (kg)	Weight (N) on Earth	Calculation
1	9.8	$1 \times 9.8 = 9.8$
2	19.6	$2 \times 9.8 = 19.6$
5	49.0	$5 \times 9.8 = 49.0$
10	98.0	$10 \times 9.8 = 98.0$
20	196.0	$20 \times 9.8 = 196.0$

Weight vs. Mass on Earth



Straight line → Weight increases directly with mass.

KEY TAKEAWAY

1. Mass is the amount of matter and stays the same everywhere.
2. Weight is the pull of gravity and can change.
3. On Earth, $W = m \times g$, where g ≈ 9.8 N/kg.

Effects of Gravity

Gravity has powerful effects that **shape our world and the universe.**

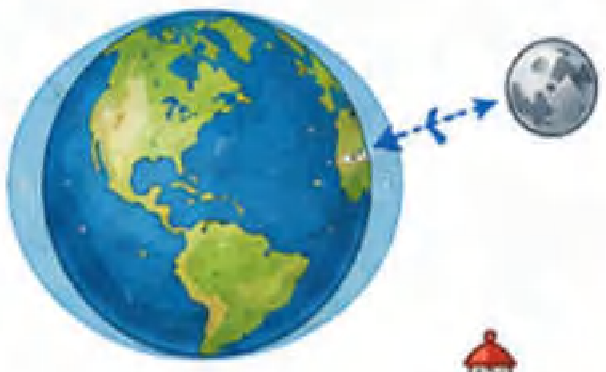
Gravity helps **maintain stability** on Earth and throughout the universe.

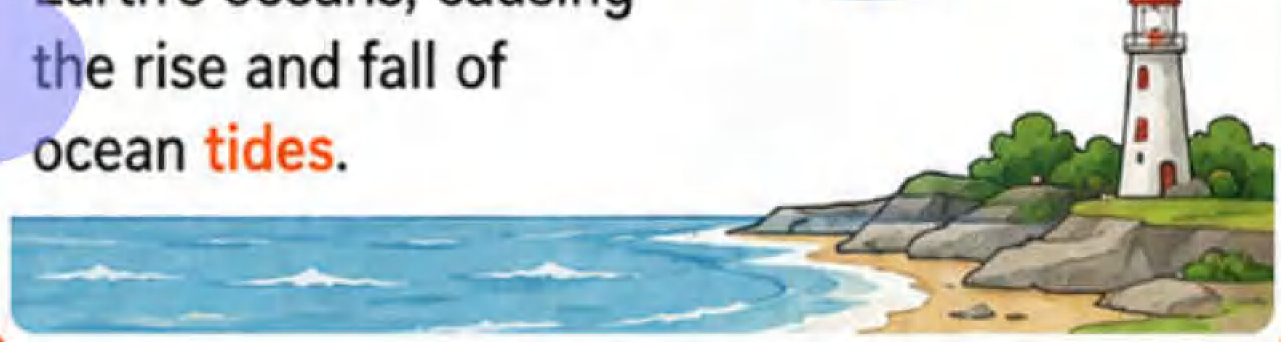
1 Keeps Objects Stable on Earth's Surface

Gravity pulls objects **downward**, keeping them on the ground and preventing them from floating away.

2 Causes Tides in Oceans

Gravity from the Moon (and the Sun) pulls on Earth's oceans, causing the rise and fall of ocean **tides**.



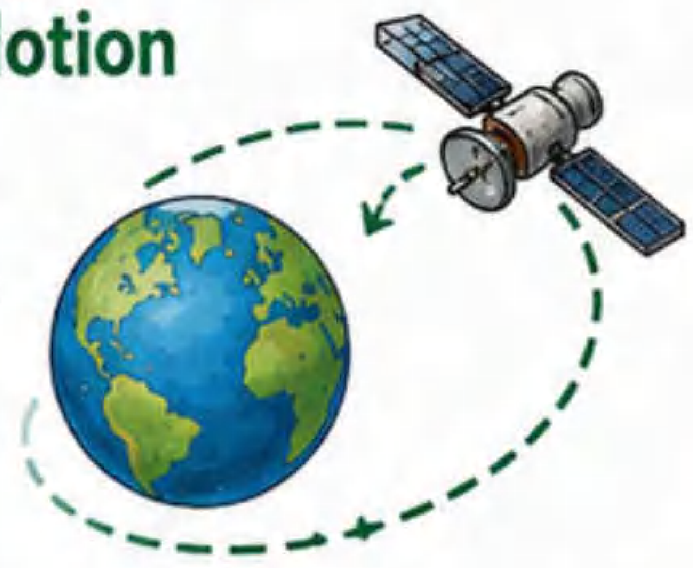


3 Forms Black Holes

When massive stars collapse, gravity becomes extremely strong, creating **black holes** that can trap even light.

4 Keeps Objects in Orbital Motion

Gravity pulls objects toward larger bodies, while their forward motion keeps them in **orbit**.



KEY TAKEAWAY

1. Keeps objects stable on Earth.
2. Causes ocean tides.
3. Forms black holes.
4. Keeps objects in orbital motion.

Weight = Mass × Gravity

Weight is the **gravitational force** acting on an object.
It depends on **mass** and the strength of **gravity (g)**.

Weight

$$W = m \times g$$

W = weight (N)
m = mass (kg)
g = gravitational field strength (N/kg)

Mass

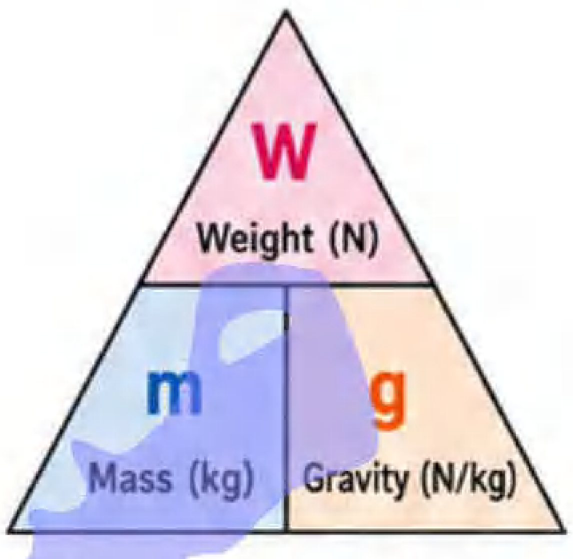
$$m = \frac{W}{g}$$

m = mass (kg)
W = weight (N)
g = gravitational field strength (N/kg)

Gravity (g)

$$g = \frac{W}{m}$$

g = gravitational field strength (N/kg)
W = weight (N)
m = mass (kg)



Cover one quantity to find the other.

Near Earth's surface, the gravitational field strength (g) is approximately **10 N/kg**. We use: $g \approx 10$ N/kg for most calculations on Earth.

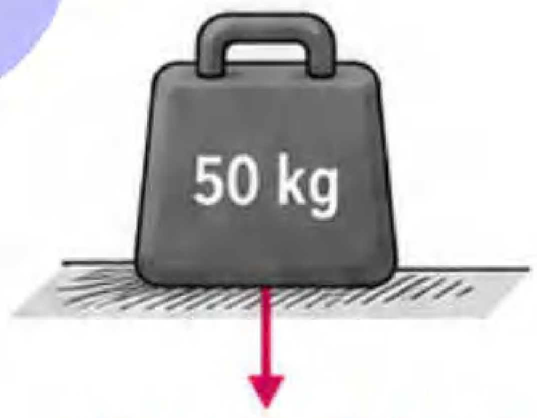
1 Worked Example

A body has a **mass** of **50 kg**.
What is its **weight** on Earth?

Given:
m = 50 kg
g = 10 N/kg (on Earth)

Solution:

$$W = m \times g$$
$$W = 50 \times 10$$
$$W = \boxed{500 \text{ N}}$$



Weight = 500 N

Therefore, the **weight** of the body on Earth is **500 N**.

2 Try This

A backpack has a **weight** of 120 N on Earth.
What is its **mass**?

Given:
W = 120 N
g = 10 N/kg

Solution:

$$m = W / g$$
$$m = 120 / 10$$
$$\boxed{m = 12 \text{ kg}}$$

Your Turn:
If an object has a weight of **300 N** on Earth, what is its mass?
______ kg

Weight Depends On...

- **Mass:** More mass → more weight.
- **Gravity (g):** Stronger gravity → more weight.
- **Place:** Same mass, different gravity → different weight.

Place	Typical g (N/kg)	Weight of 50 kg Mass
Earth (near surface)	10	500 N
Moon	1.6	80 N
Mars	3.7	185 N

KEY TAKEAWAY

① **Weight** is the pull of gravity on an object.

② Use $W = m \times g$ and remember $g \approx 10$ N/kg on Earth.

③ Same **mass**, different places → different **weight**.

Electric, Magnetic and Gravitational Forces

Electric, magnetic and gravitational forces are all **field forces**.
They act at a distance through invisible fields.

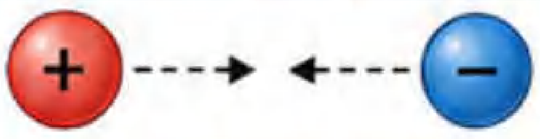
1 Electric Force

Acts between **electric charges**.

Nature

Can be **attraction** or **repulsion**.

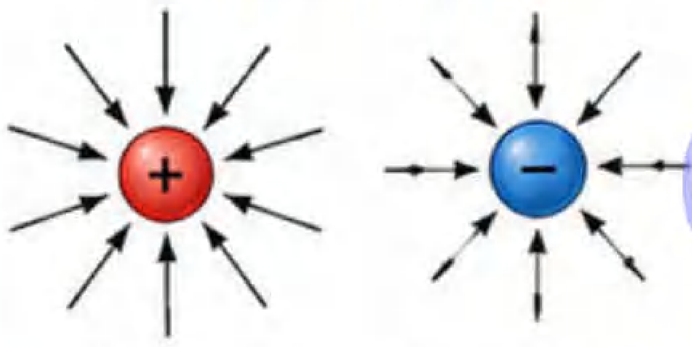
Opposite charges attract



Like charges repel

Represented by

an **electric field**.



Field lines show the direction of force on a positive charge.

Examples

Static electricity

Balloon attracting paper bits

Lightning storms

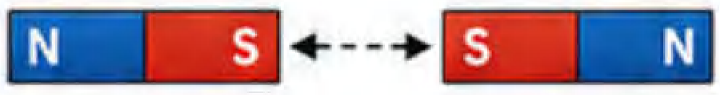
2 Magnetic Force

Acts due to **magnets or magnetic materials**.

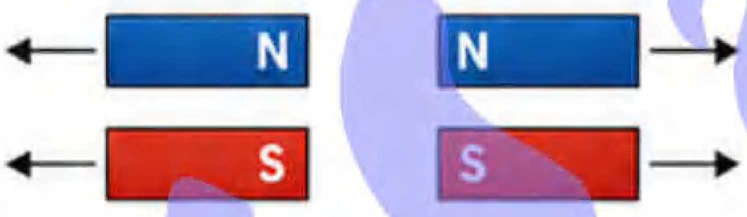
Nature

Can be **attraction** or **repulsion**.

Opposite poles attract

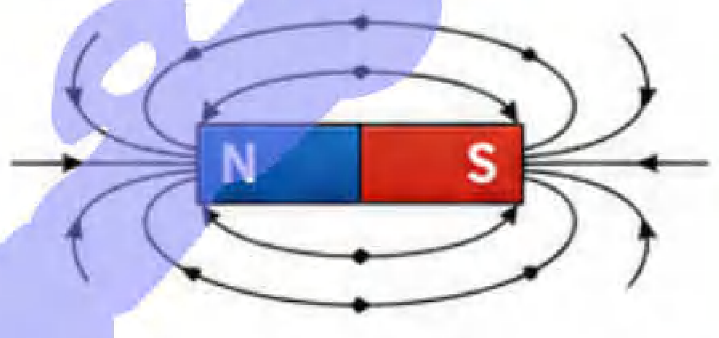


Like poles repel



Represented by

a **magnetic field**.



Field lines go from the North pole (N) to the South pole (S) outside the magnet.

Examples

Bar magnets

Compass needle

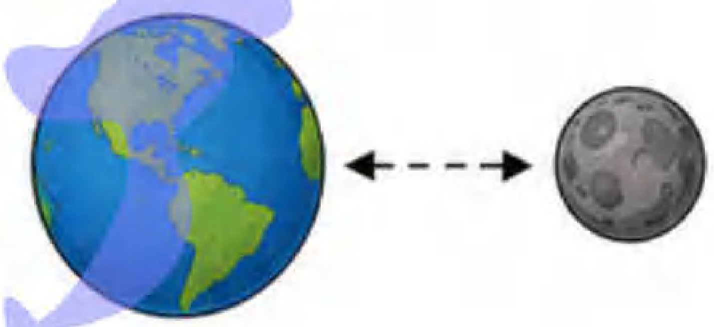
Electric motors

3 Gravitational Force

Acts between **masses**.

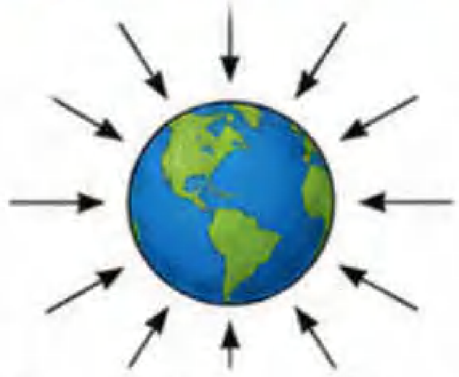
Nature

Attraction only.



Represented by

a **gravitational field**.



Field lines point toward the mass.
Stronger field lines are closer together.

Examples

Falling objects

Planets orbiting the Sun

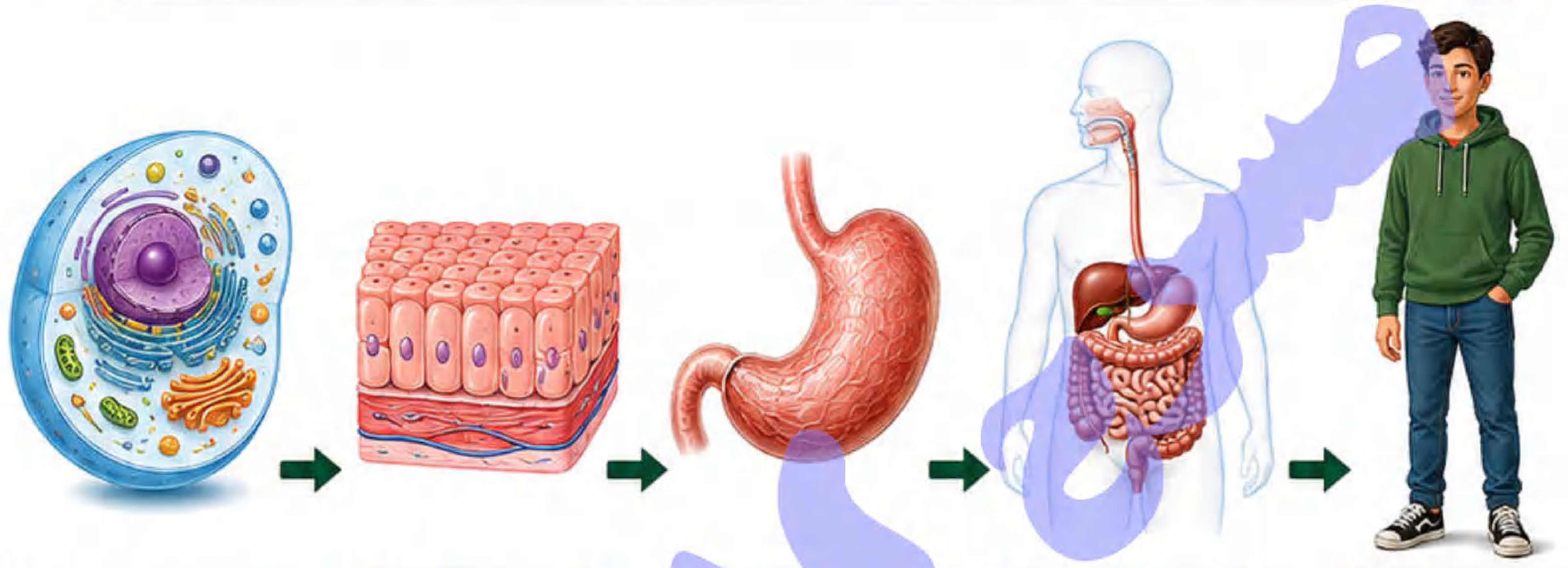
Tides in the ocean

KEY SUMMARY

Acts between	Electric charges	Magnets or magnetic materials	Masses
Can be attraction or repulsion?	✓ Yes, both	✓ Yes, both	✗ No, attraction only
Represented by	Electric field	Magnetic field	Gravitational field

The Cell: Unit of Life

The cell is the structural and functional unit of a living organism.



1. Cell	2. Tissue	3. Organ	4. System	5. Living Organism
the basic unit of structure and function.	a group of similar cells working together.	different tissues working together for a specific function.	a group of organs working together to perform major functions.	all systems working together to sustain life.

KEY IDEA

Living organisms are organized in hierarchical levels of increasing complexity, starting from cells. Each level builds on the one below it, allowing life to function efficiently.

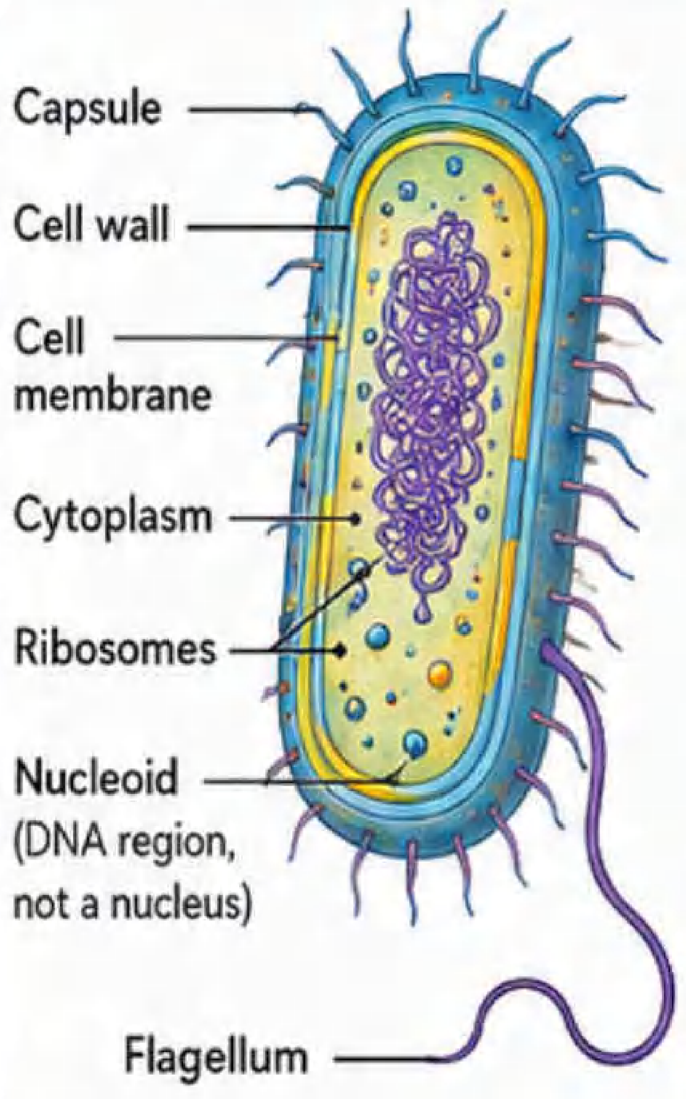
REMEMBER

- All living things are made of one or more cells.
- Cells are organized into tissues, organs, and systems.
- Structure and function are connected at every level of organization.

Three Main Cell Types

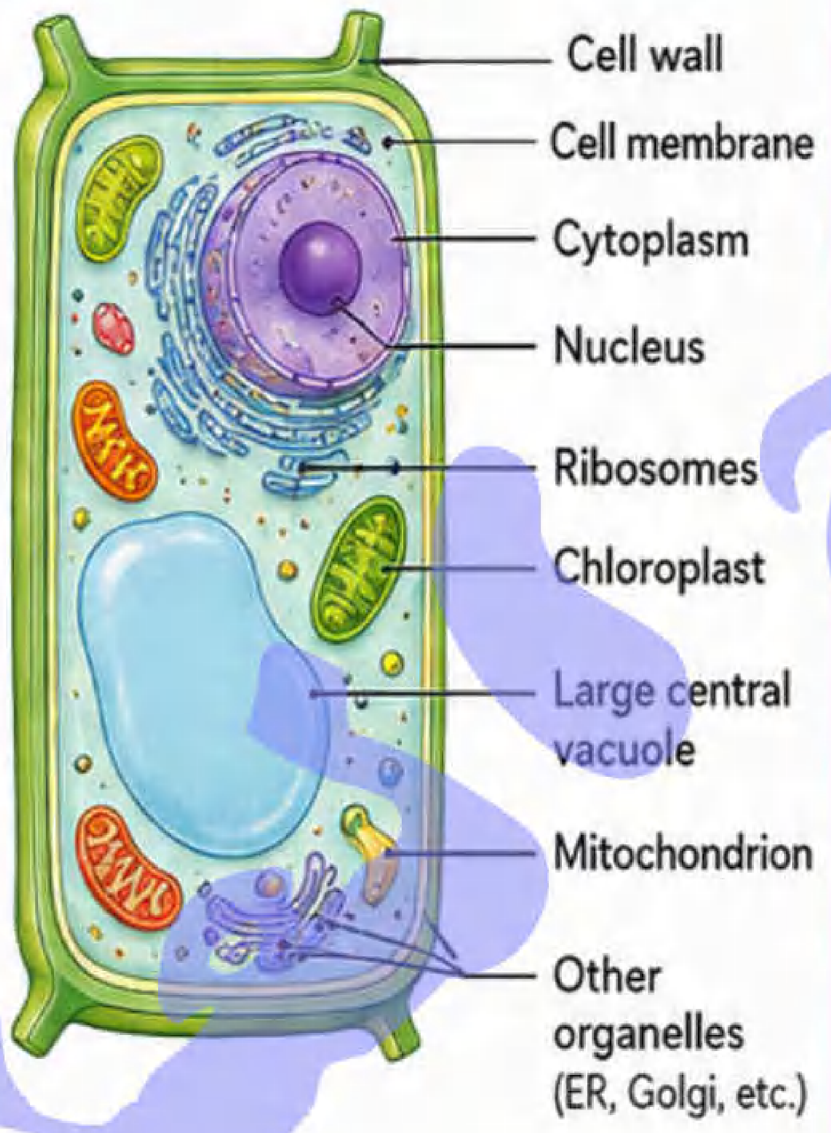
Bacterial, Plant and Animal Cells

1. Bacterial Cell


Capsule
Cell wall
Cell membrane
Cytoplasm
Ribosomes
Nucleoid (DNA region, not a nucleus)
Flagellum

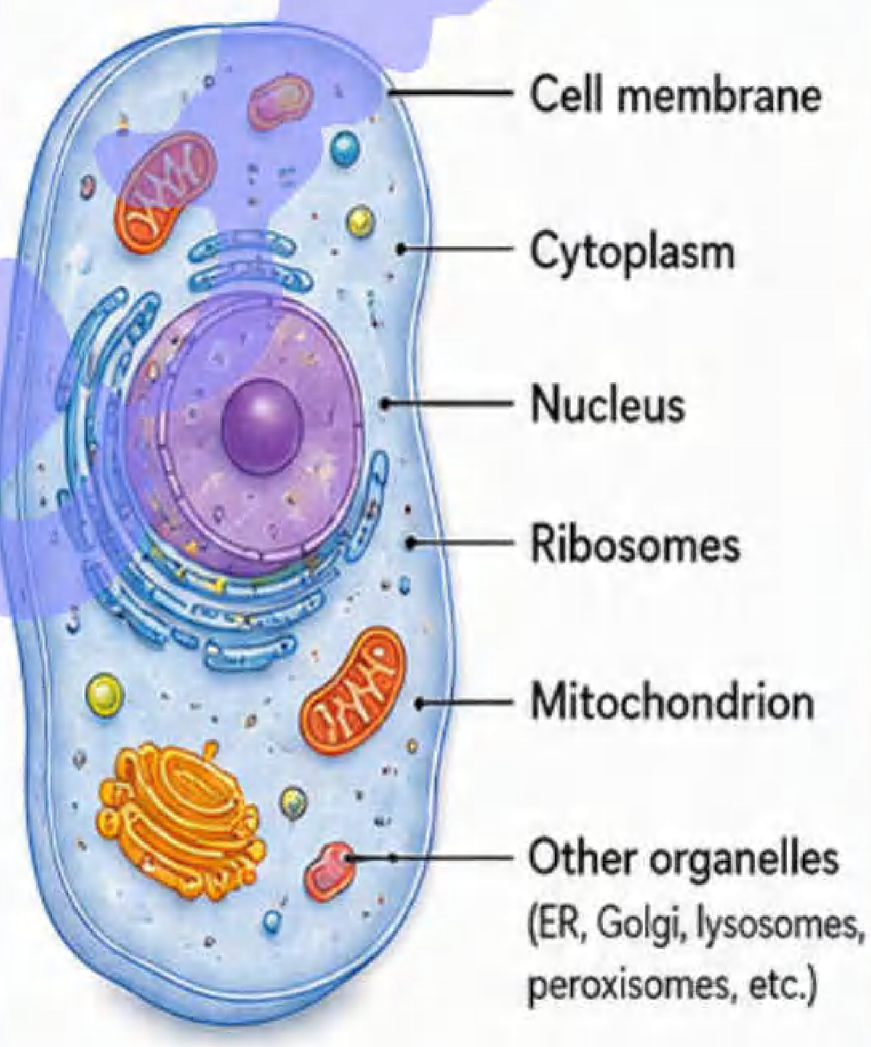
Prokaryotic cells. They do not have a true nucleus or membrane-bound organelles.

2. Plant Cell


Cell wall
Cell membrane
Cytoplasm
Nucleus
Ribosomes
Chloroplast
Large central vacuole
Mitochondrion
Other organelles (ER, Golgi, etc.)

Eukaryotic cells with a cell wall, chloroplasts, and a large central vacuole for storage.

3. Animal Cell


Cell membrane
Cytoplasm
Nucleus
Ribosomes
Mitochondrion
Other organelles (ER, Golgi, lysosomes, peroxisomes, etc.)

Eukaryotic cells. They do not have a cell wall or chloroplasts, and often have small vacuoles.

SHARED STRUCTURES

All three cell types have:

- ✓ **Cell membrane** – controls what enters and leaves the cell.
- ✓ **Cytoplasm** – jelly-like fluid where reactions occur.
- ✓ **Ribosomes** – tiny structures that make proteins.

MAIN DIFFERENCES

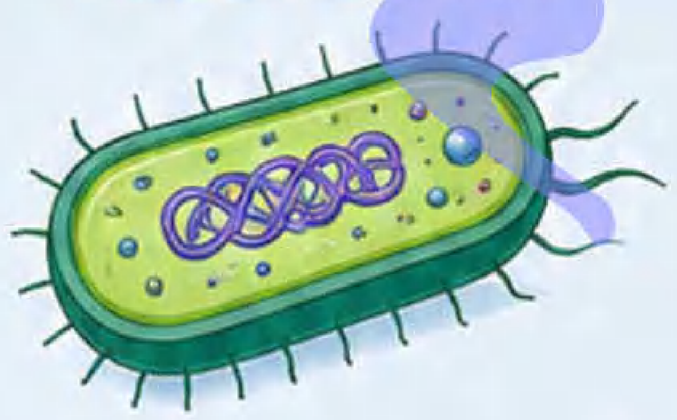
- Bacterial cells are prokaryotic: no true nucleus or membrane-bound organelles.
- Plant cells have a cell wall, chloroplasts, and a large central vacuole.
- Animal cells lack a cell wall and chloroplasts; they have small vacuoles and different organelles.

Comparing Bacterial, Plant and Animal Cells

Shared features and key differences.

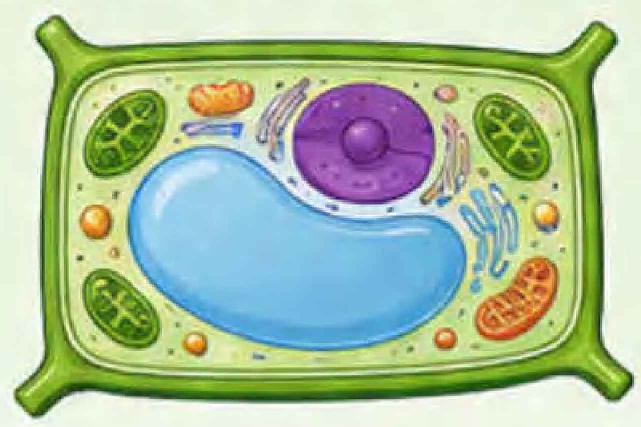
Feature	Bacterial Cell	Plant Cell	Animal Cell
Cell membrane	✓	✓	✓
Cytoplasm	✓	✓	✓
Ribosomes	✓	✓	✓
True nucleus	✗	✓	✓
Mitochondria	✗	✓	✓
Golgi apparatus / ER	✗	✓	✓
Cell wall	✓	✓	✗
Chloroplasts	✗	✓	✗
Large vacuole	✗	✓	✗

Bacterial Cell



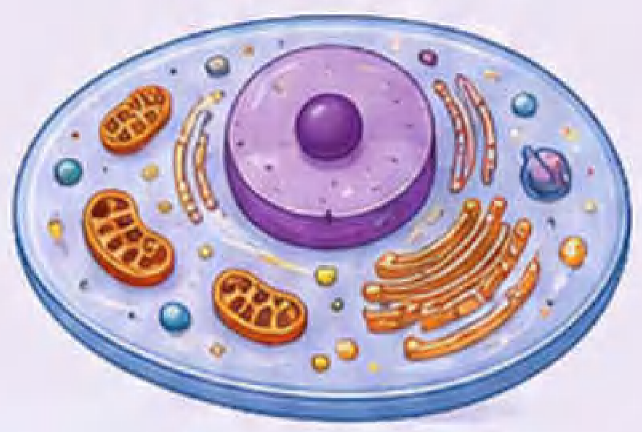
Small and simple; no true nucleus or membrane-bound organelles; cell wall present.

Plant Cell



Has a cell wall, chloroplasts, and a large vacuole for support and photosynthesis.

Animal Cell



No cell wall or chloroplasts; flexible shape; many kinds of organelles perform functions.

Classification of Living Organisms

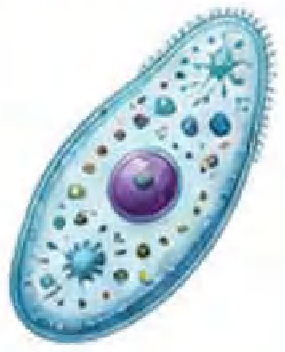
Why scientists classify living things

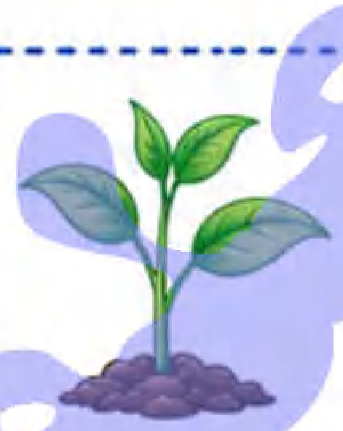
Classification arranges living organisms into groups according to **similarities** and **differences** to make study and identification easier.

Major classification clues

1 Number of cells

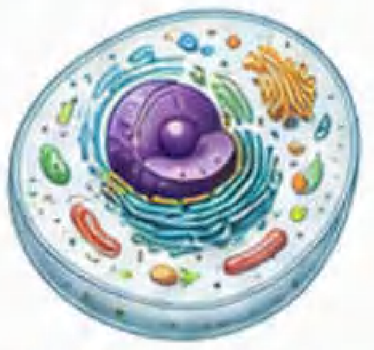
Some organisms are made of one cell. Others are made of many cells.

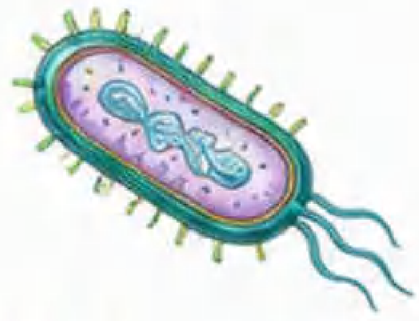

One-celled


Many-celled

2 Nucleus structure

Cells can have a true nucleus (with a membrane) or have no nucleus.


With nucleus (Eukaryotes)


Without nucleus (Prokaryotes)

Benefits of classification

Make study easier

Grouping organisms helps scientists organize information and study them more efficiently.

Recognize relationships

It shows how organisms are related based on shared characteristics and common ancestry.

Identify organisms

Classification helps scientists identify unknown organisms using their features.

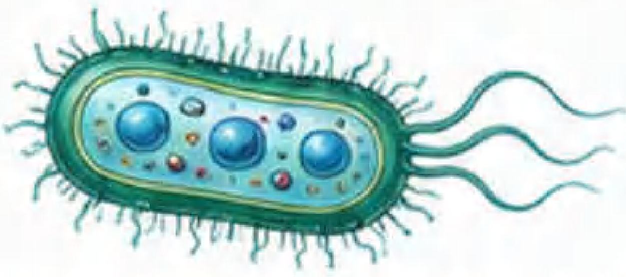
Unicellular and Multicellular Organisms

Classification according to number of cells

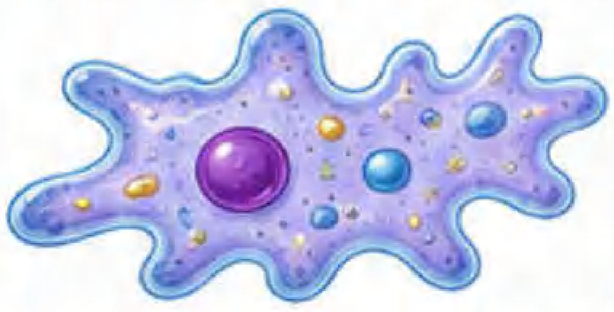
Unicellular Organisms

one cell carries out all life processes.

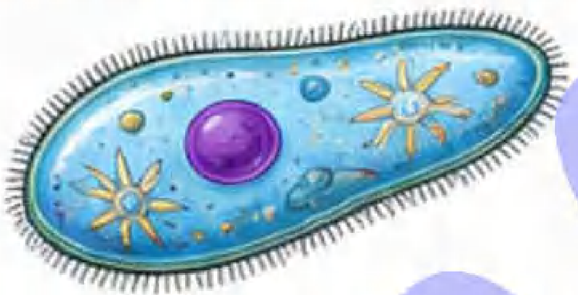
Examples



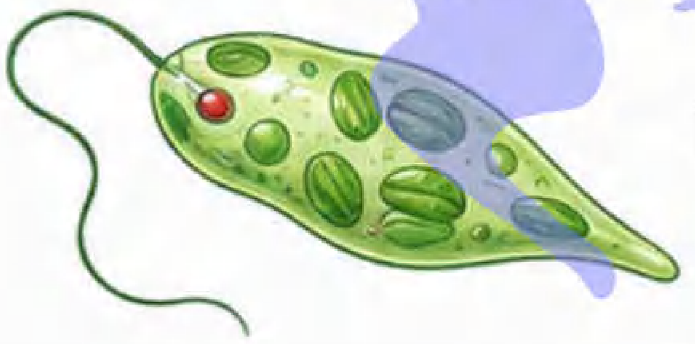
Bacterium



Amoeba



Paramecium

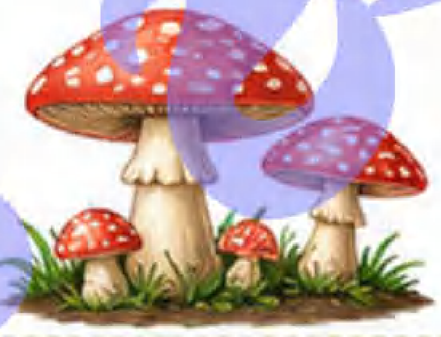


Euglena

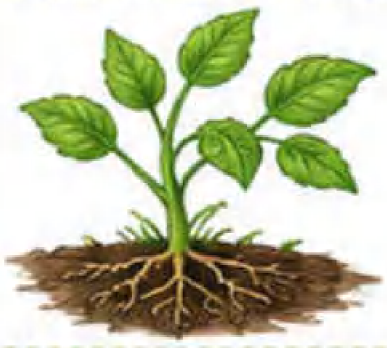
Multicellular Organisms

many cells work together and may become specialized.

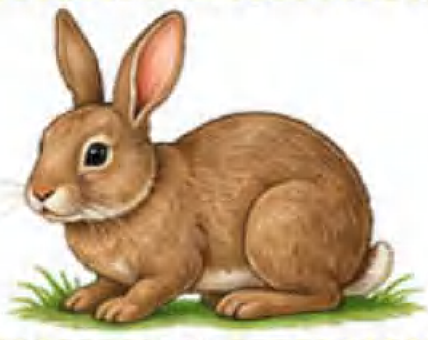
Examples



Fungus

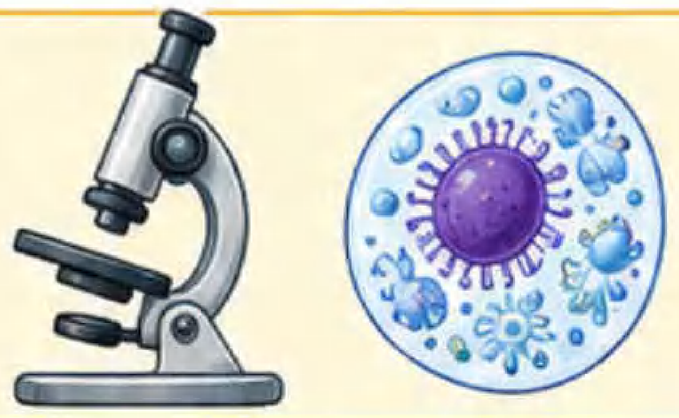


Plant



Animal

Human



Microscopic Organisms

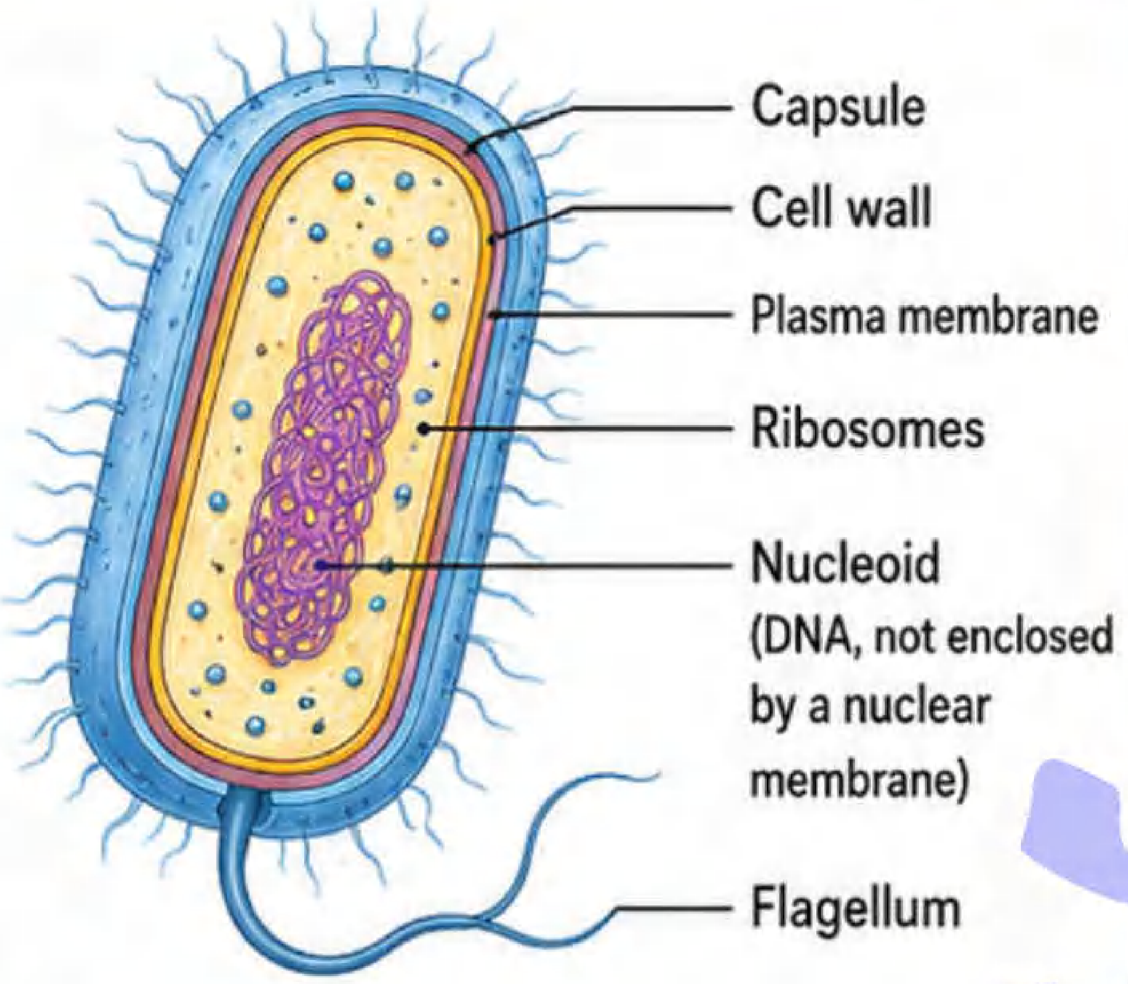
Many unicellular organisms are microscopic—too small to be seen with the naked eye. They are studied using a **microscope**.

Examples: bacteria, amoeba, paramecium, euglena.

Prokaryotes and Eukaryotes

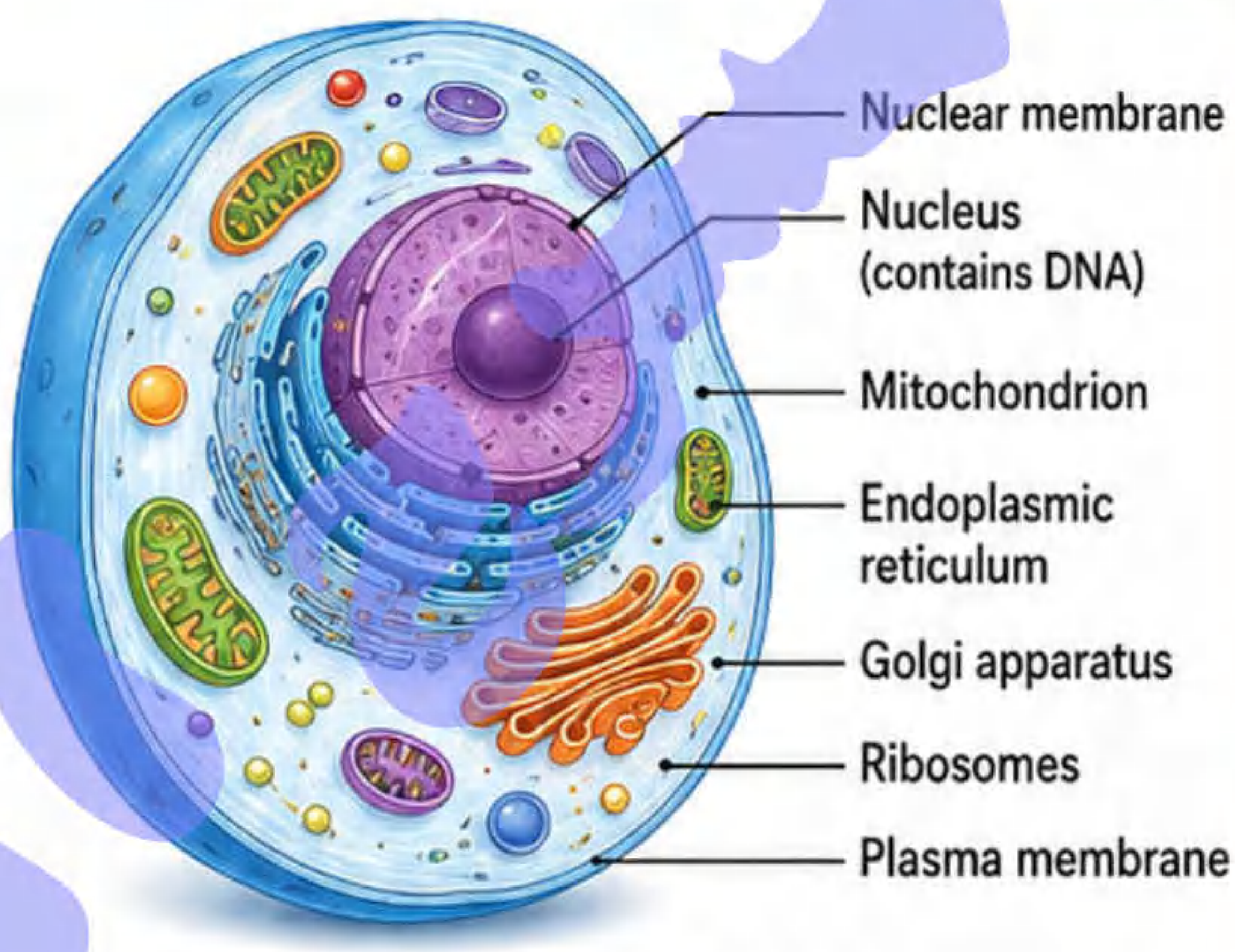
Classification according to **nucleus structure**

Prokaryotic Cell


Capsule
Cell wall
Plasma membrane
Ribosomes
Nucleoid
(DNA, not enclosed by a nuclear membrane)
Flagellum

- Genetic material not enclosed by a true nuclear membrane.
- Simpler and usually smaller.
- Bacteria are the main example in this lesson.

Eukaryotic Cell

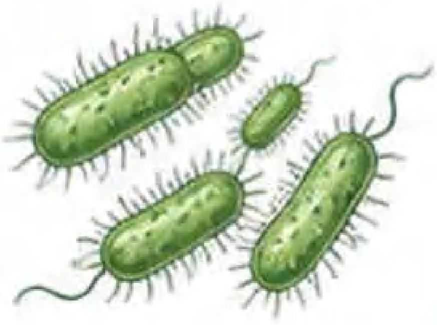

Nuclear membrane
Nucleus
(contains DNA)
Mitochondrion
Endoplasmic reticulum
Golgi apparatus
Ribosomes
Plasma membrane

- Genetic material enclosed in a true nucleus surrounded by a nuclear membrane.
- More complex and have many organelles.
- May be unicellular or multicellular.

Examples

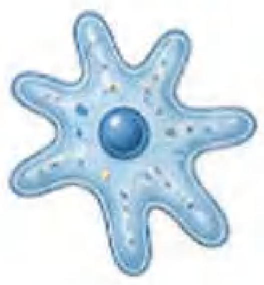
Prokaryote

Bacteria

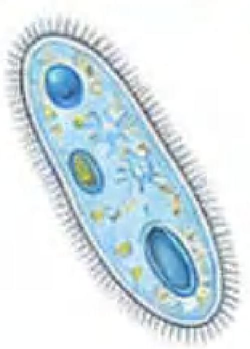


Eukaryotic Unicellular

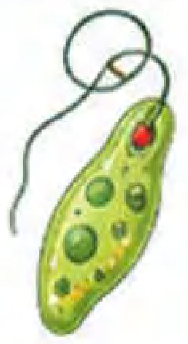
Amoeba



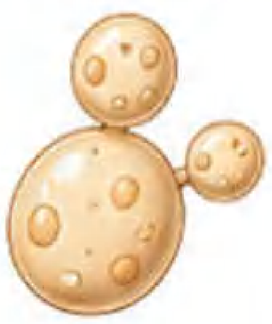
Paramecium



Euglena



Yeast



Eukaryotic Multicellular

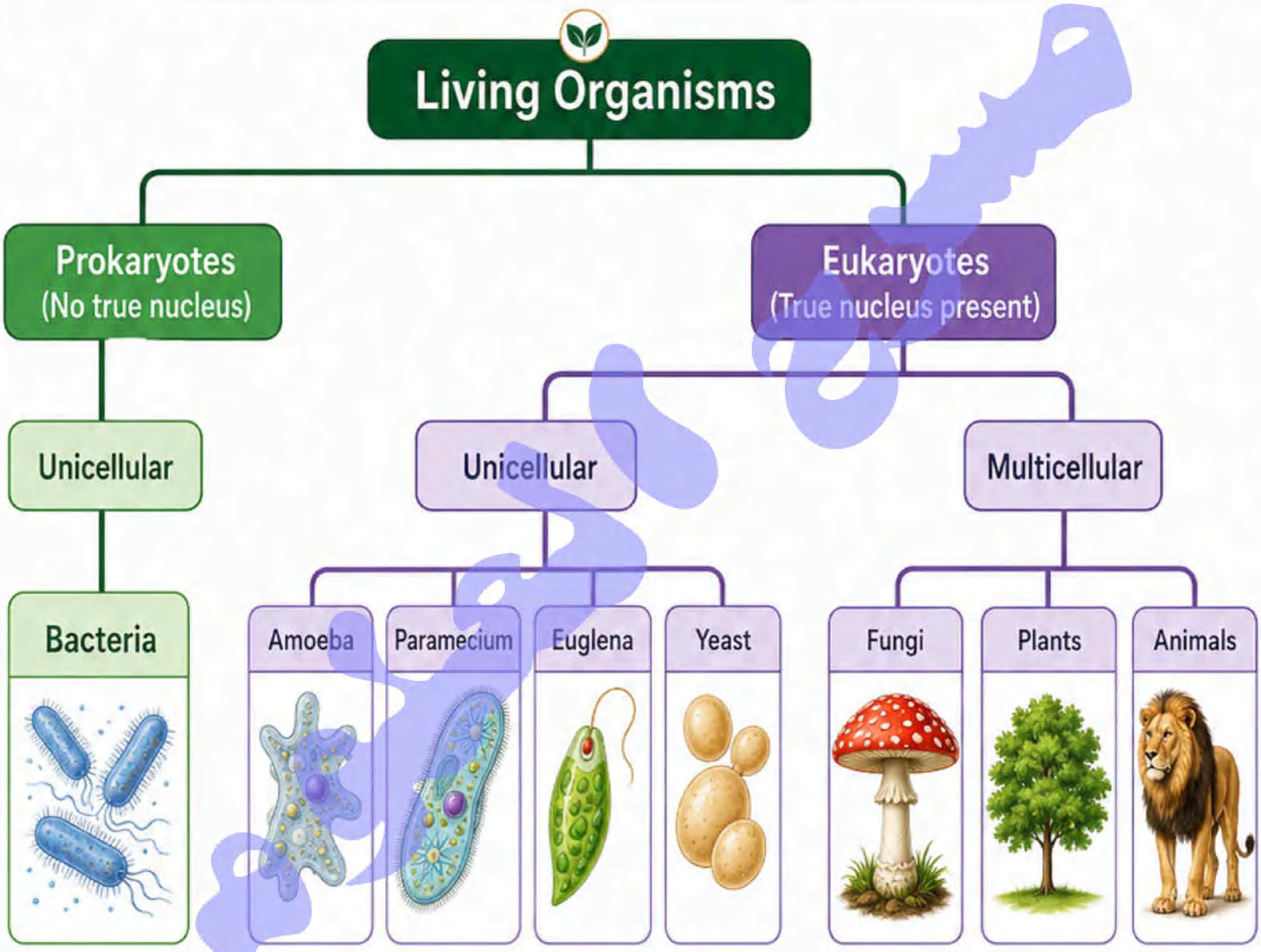
Fungi

Plants

Animals

Classification by Nucleus Structure

A complete map of the organisms in this lesson.

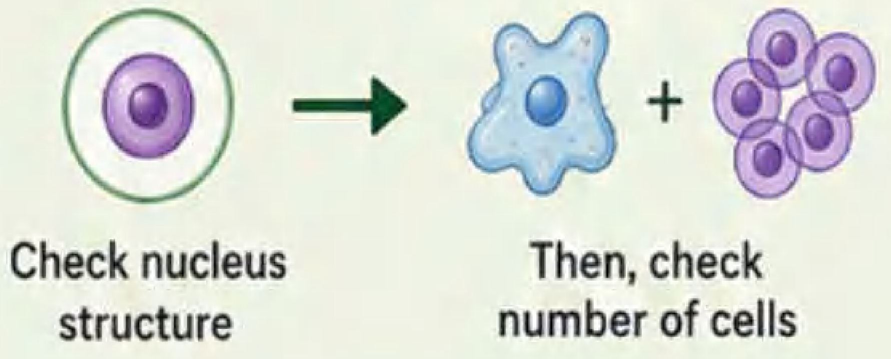


Living Organisms

- **Prokaryotes** (No true nucleus)
  - Unicellular
    - Bacteria
- **Eukaryotes** (True nucleus present)
  - Unicellular
    - Amoeba
    - Paramecium
    - Euglena
    - Yeast
  - Multicellular
    - Fungi
    - Plants
    - Animals

HOW TO READ THIS MAP:

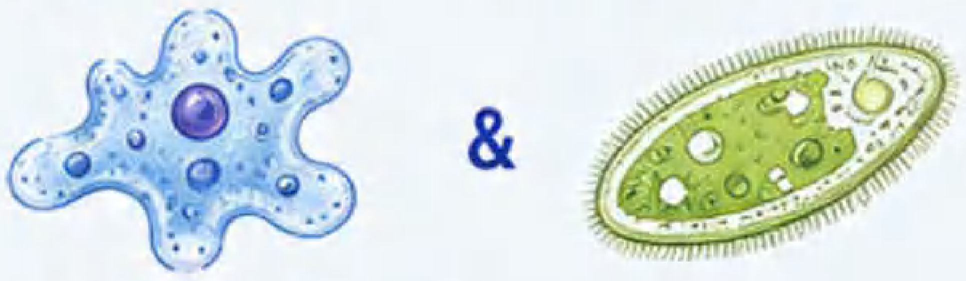
1. First, check the nucleus structure (Prokaryotes or Eukaryotes).
2. Then, check the number of cells (Unicellular or Multicellular).
3. Finally, identify the organism in its correct group.


Check nucleus structure
Then, check number of cells

How to Identify and Compare Organisms

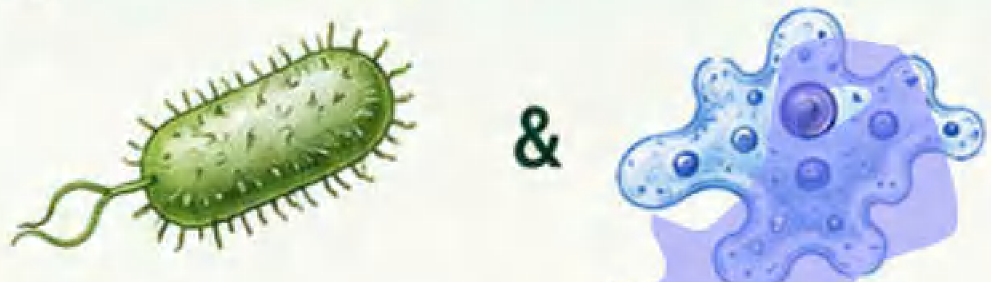
Reading information from the classification map

1 Amoeba & Paramecium



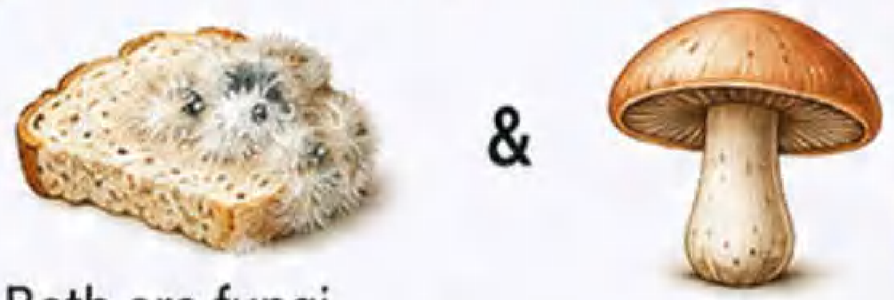
- Both are eukaryotic.
- Both are unicellular.
- Both belong to the group Protists.

2 Bacteria & Amoeba



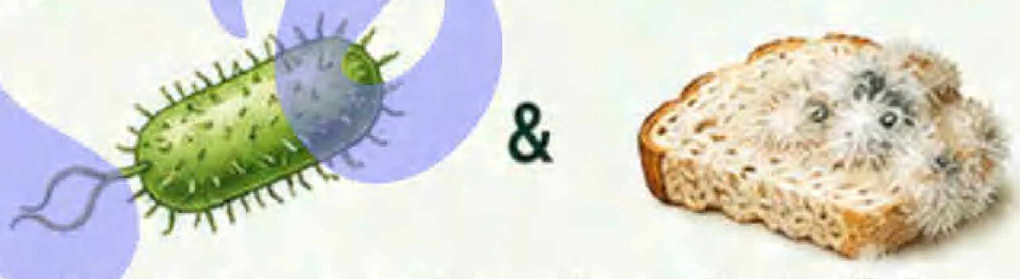
- Both are unicellular.
- Bacteria are prokaryotic (no nucleus).
- Amoeba is eukaryotic (has a nucleus).

3 Bread Mold & Mushroom



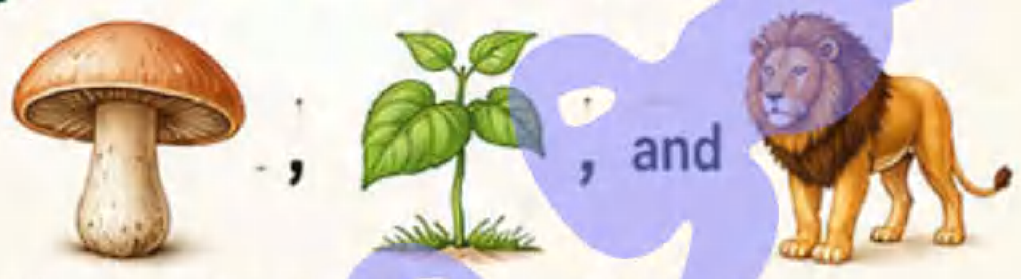
- Both are fungi.
- Both are multicellular and eukaryotic.
- They have cell walls made of chitin.

4 Bacteria & Bread Mold



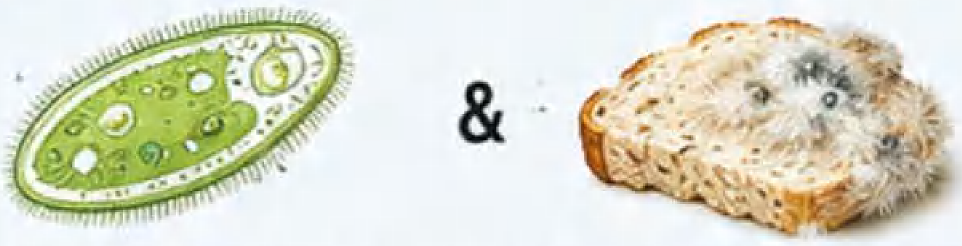
- Bacteria are prokaryotic and unicellular.
- Bread mold is eukaryotic and multicellular.
- They belong to different groups.

5 Mushroom, Bean, and Lion



- All are eukaryotic and multicellular.
- They belong to different groups: Fungi (mushroom), Plants (bean), Animals (lion).

6 Paramecium & Bread Mold



- Paramecium is unicellular; bread mold is multicellular.
- Both are eukaryotic.
- They belong to different groups.

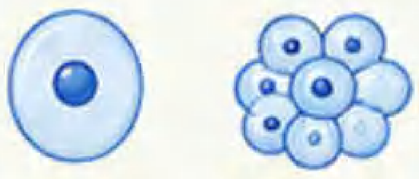
QUICK RULE: FOLLOW THESE 3 STEPS

① Check nucleus structure.

If it has a nucleus, it's eukaryotic.

→

② Check number of cells.



Is it one cell (unicellular) or many cells (multicellular)?

→

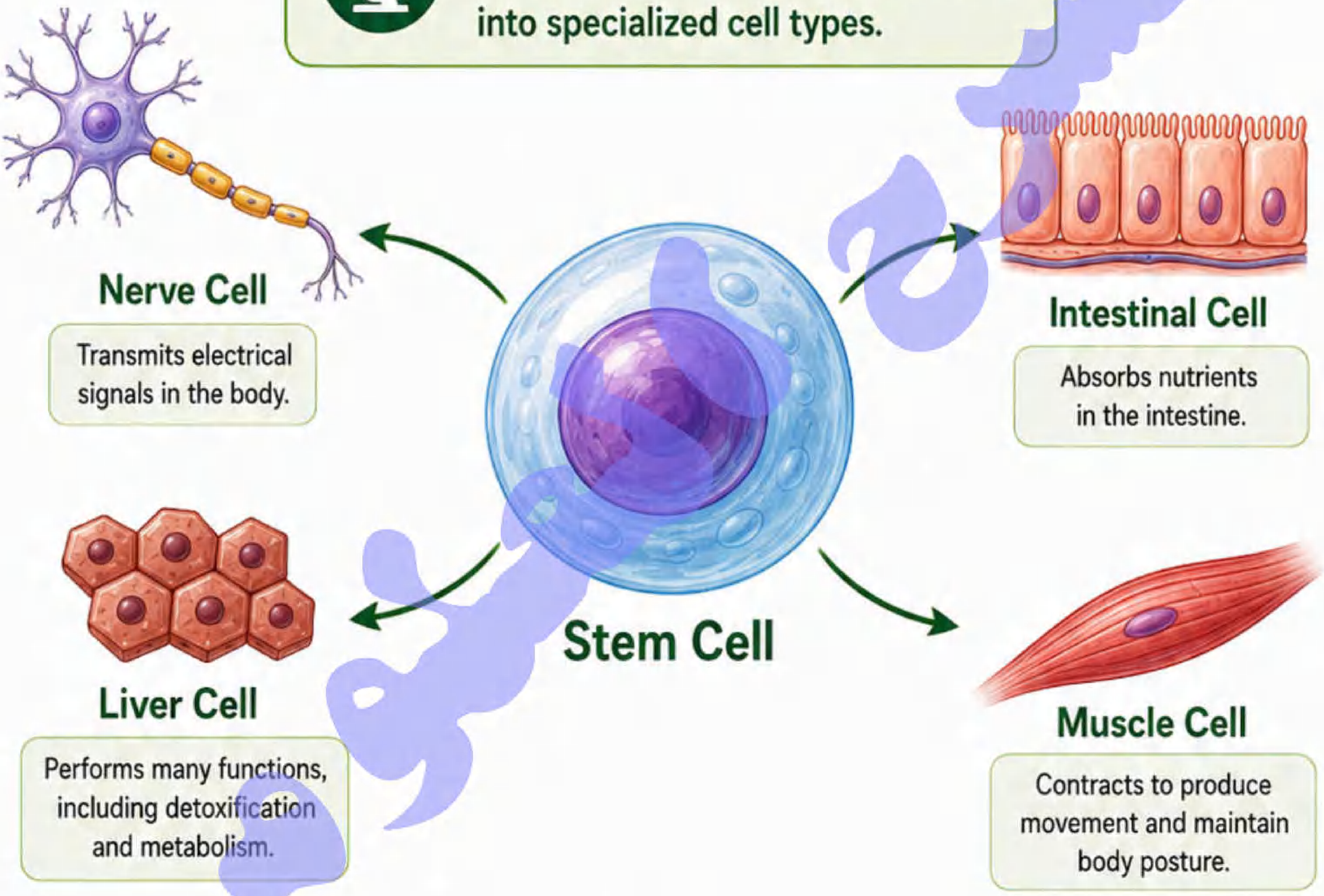
③ Match the organism to its group.

Use the classification map to find its group.

Stem Cells

Cells that can **renew themselves** and form **specialized cells.**

Stem cells can divide to produce new stem cells and can differentiate into specialized cell types.



Nerve Cell

Transmits electrical signals in the body.

Intestinal Cell

Absorbs nutrients in the intestine.

Stem Cell

Liver Cell

Performs many functions, including detoxification and metabolism.

Muscle Cell

Contracts to produce movement and maintain body posture.

Self-renewal

Stem cells can divide to produce new stem cells identical to themselves, maintaining the stem cell pool.

Differentiation

Stem cells can change into specialized cell types with specific structures and functions needed by the body.

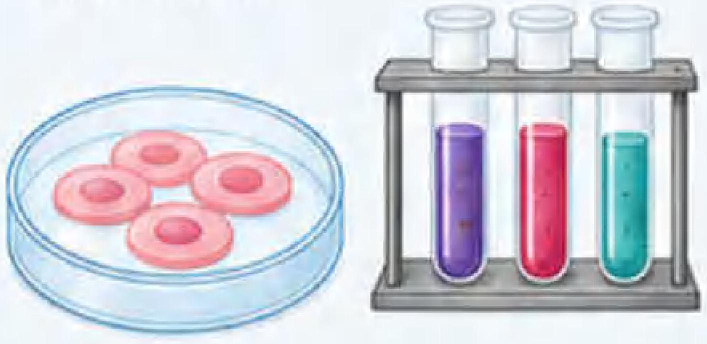
Stem Cells & Final Lesson Review

From cell structure to classification and specialization.

Why Stem Cells Are Important

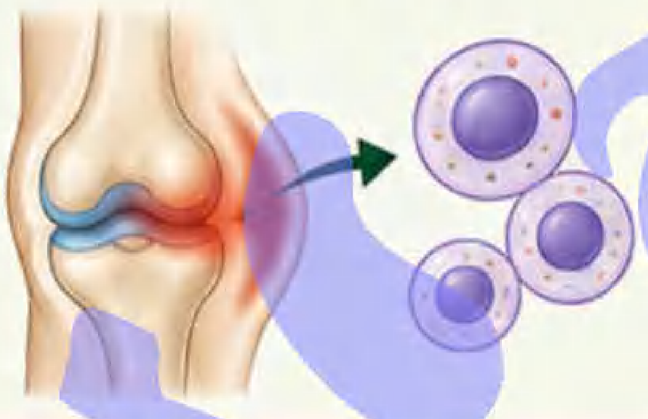
1. Research

Stem cells help scientists study how cells develop, how diseases occur, and test new treatments and medicines.



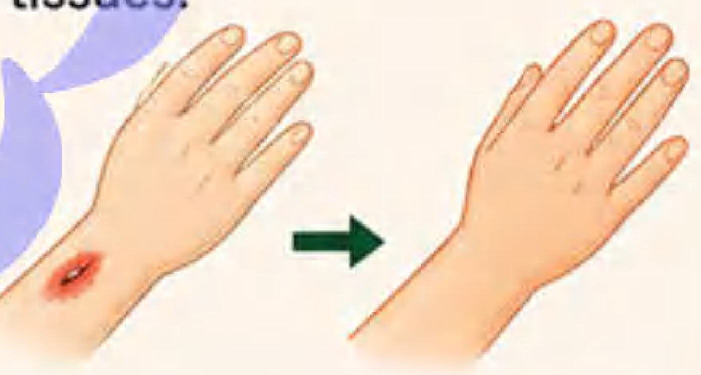
2. Replacement of damaged cells

Stem cells can develop into specialized cells to replace cells that are damaged by injury, disease, or aging.



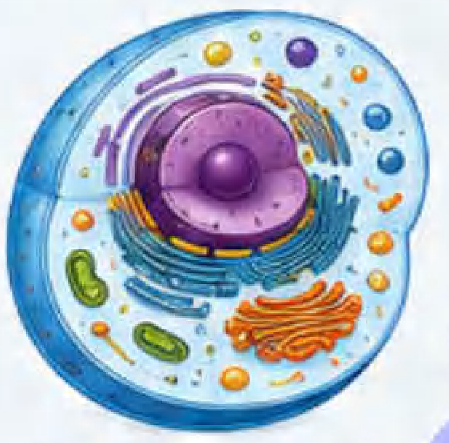
3. Understanding growth and tissue repair

They help us understand how the body grows, heals wounds, and maintains healthy tissues.



Final Lesson Review – Concept Map

1 The cell is the unit of life



The basic structural and functional unit of all living things.

2 Main cell types

Bacterial (Prokaryotic)

Plant (Eukaryotic)

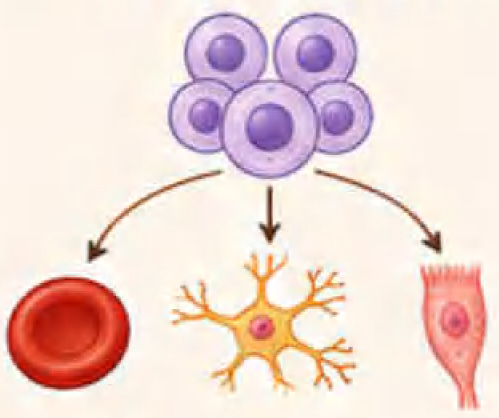
Animal (Eukaryotic)

3 Classification

By number of cells:
- Unicellular
- Multicellular

By cell type:
- Prokaryote
- Eukaryote

4 Stem cells: Self-renewal and Differentiation



Stem cells can make more stem cells (self-renewal) and become specialized cells (differentiation).

REMEMBER

- The cell is the basic unit of structure and function in all living organisms.
- Cells are organized from simple to complex: cells → tissues → organs → systems → organism.
- Living organisms are classified by the number of cells and by cell type.
- Stem cells are special because they can renew themselves and become different cell types.
- Understanding cells helps us understand life and how to improve health.

LESSON 1

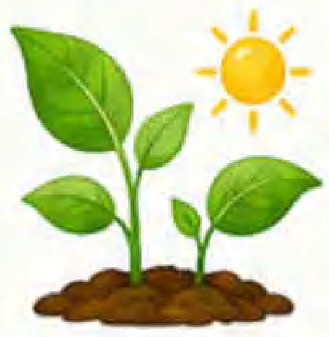
General Characteristics of Living Organisms

Living organisms share essential life processes.

Shared Characteristics of All Living Organisms

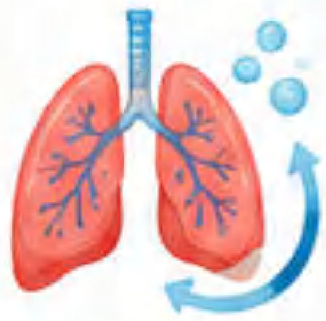
Despite their great diversity, all living organisms carry out these six essential life processes.

1 Nutrition



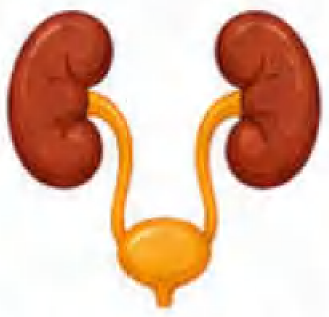
Organisms obtain food and nutrients for energy, growth and repair.

2 Respiration



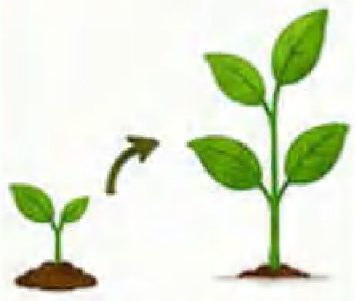
Organisms break down food to release energy for life activities.

3 Excretion



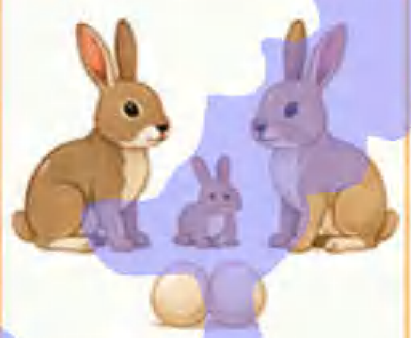
Organisms remove waste products produced during life processes.

4 Growth



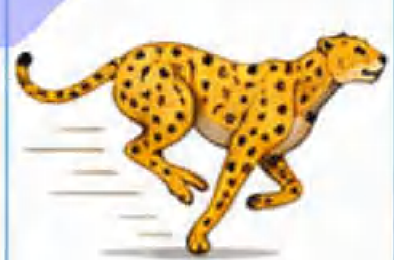
Organisms increase in size and number of cells.

5 Reproduction



Organisms produce new individuals of their own kind.

6 Movement



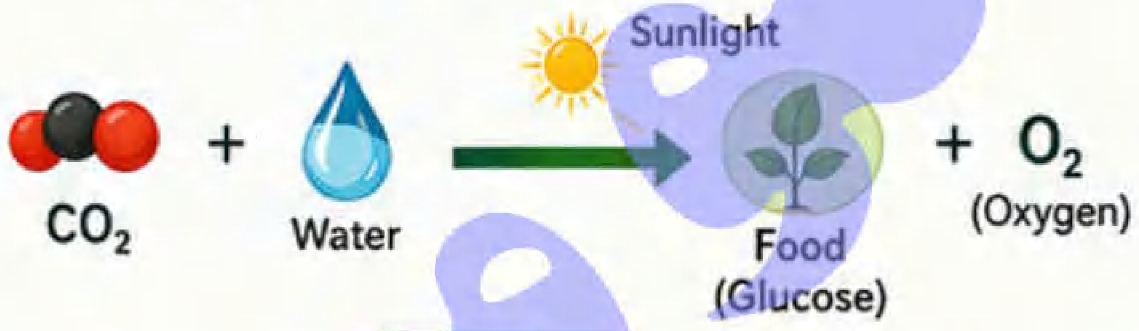
Organisms move all or part of their body from one place to another.

According to how organisms get food

Based on the source of their food, organisms are of two main types.

Autotrophic organisms

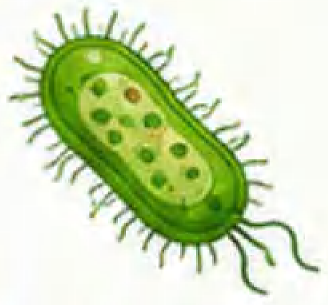
- Organisms that can make their own food using simple substances.



Examples

Green plants

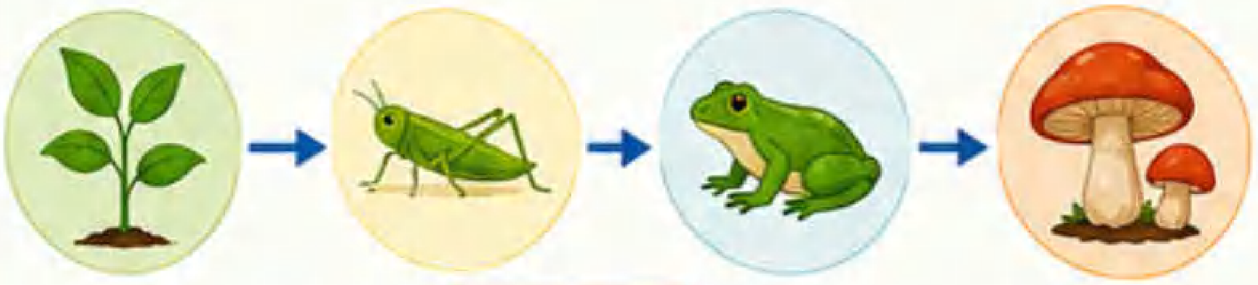
Green algae



Some bacteria
(such as cyanobacteria)

Heterotrophic organisms

- Organisms that depend on other organisms directly or indirectly for food.



Examples

Animals

Fungi

Some bacteria
(such as *E. coli*)

Living organisms may look different and live in different places, but they function through the same basic life processes.

LESSON 1 Photosynthesis

Photosynthesis is the process by which green plants make their own food.

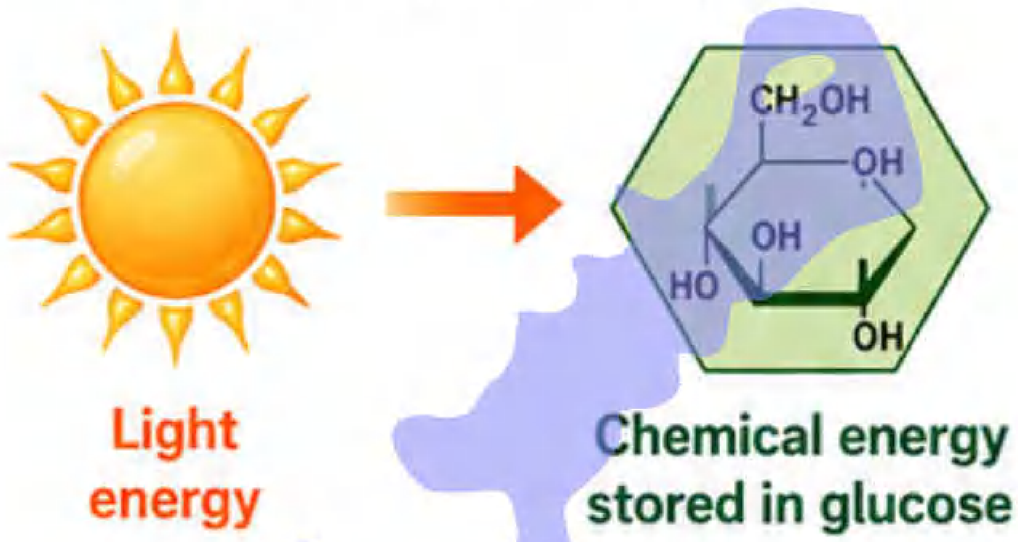
Where and When?

Occurs during **daytime** in the presence of sunlight.

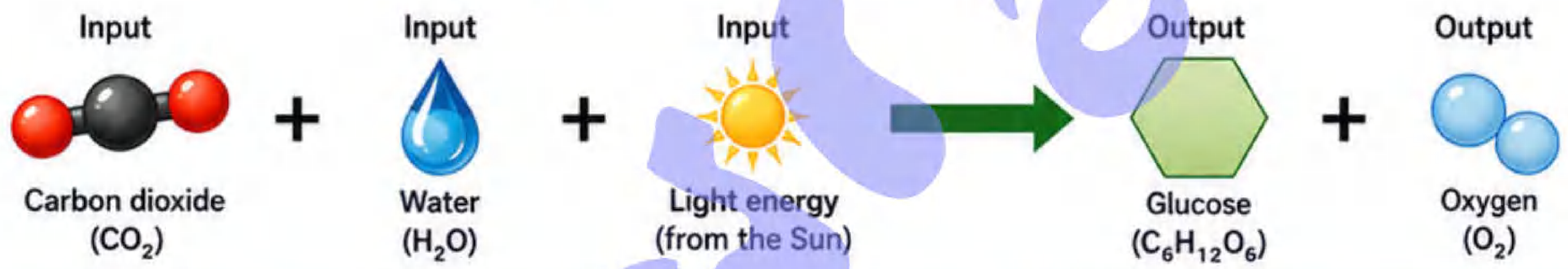
Occurs in **chloroplasts** containing **chlorophyll,** especially in green leaves.

Energy Transformation

Photosynthesis captures **light energy** from the sun and converts it into chemical energy stored in **glucose.**



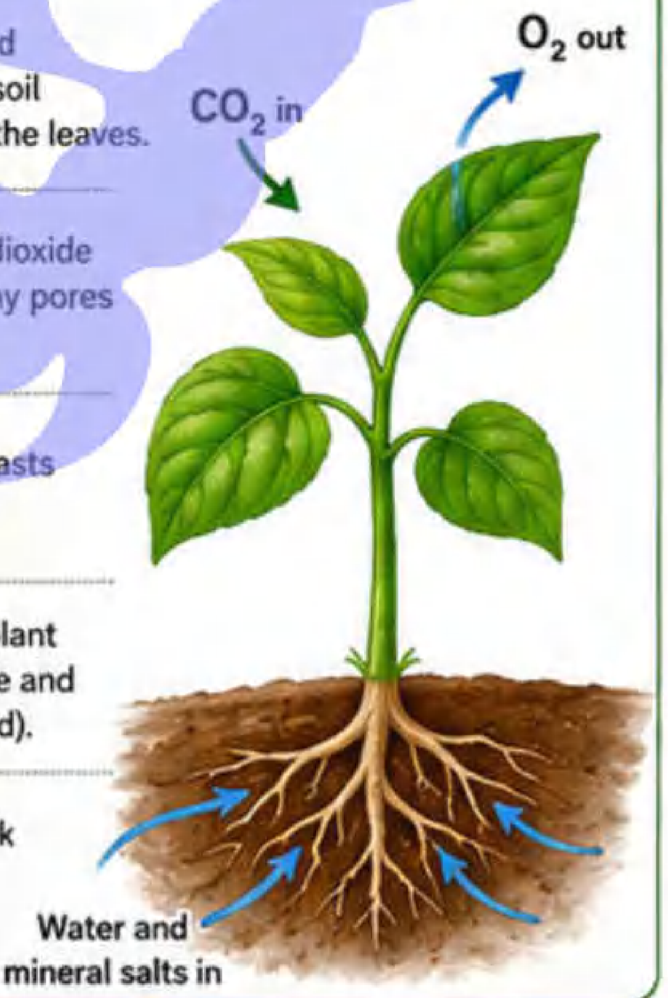
Inputs and Outputs of Photosynthesis



Carbon dioxide (CO_2) + Water (H_2O) + Light energy (from the Sun) → Glucose ($C_6H_{12}O_6$) + Oxygen (O_2)

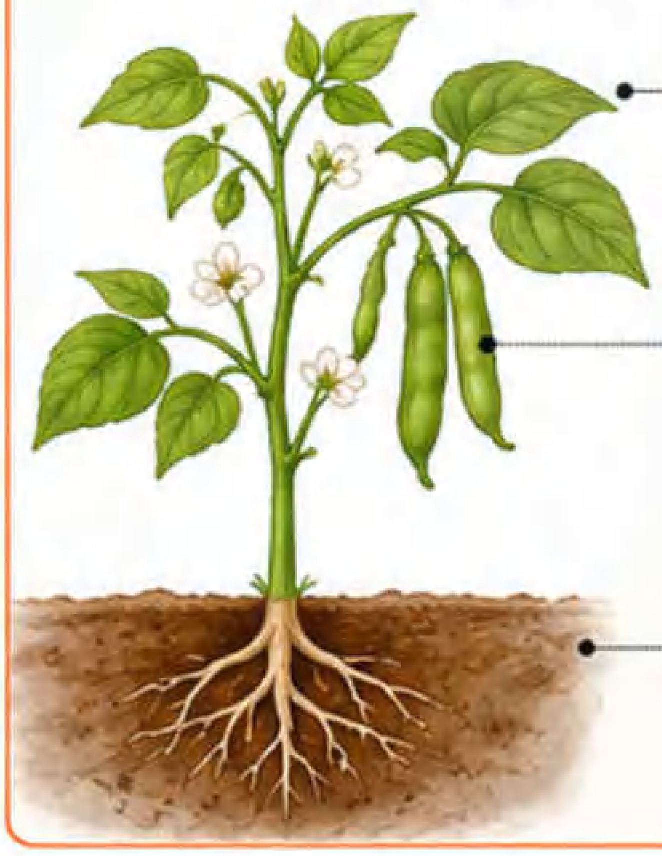
How Does Photosynthesis Happen?

1. Roots absorb water and mineral salts from the soil and transport them to the leaves.
2. Leaves take in carbon dioxide from the air through tiny pores called stomata.
3. Chlorophyll in chloroplasts absorbs sunlight.
4. Using this energy, the plant converts carbon dioxide and water into glucose (food).
5. Oxygen is released back into the air through the stomata.



Example: Bean Plant

A bean plant is a producer (autotroph). It makes its own food through photosynthesis.



Leaves: main site of photosynthesis.

Food (glucose) is made and used for growth.

Roots: absorb water and mineral salts.

KEY TAKEAWAY

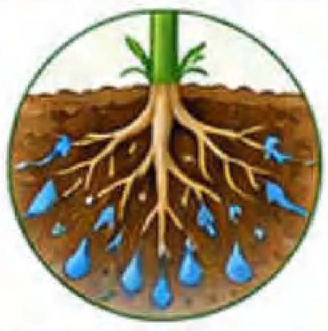
Photosynthesis is how plants produce their own food using sunlight, water and carbon dioxide. It also releases oxygen that we breathe.

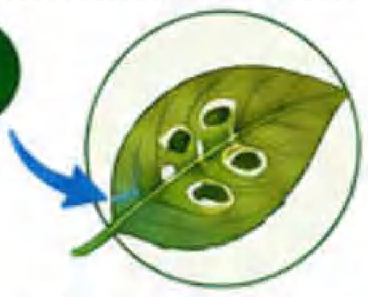
LESSON 1

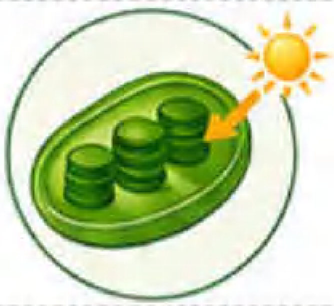
How Photosynthesis Happens

From raw materials to glucose and oxygen

Step-by-Step Process of Photosynthesis

1

Roots absorb water and mineral salts from the soil.

2

Leaves take in carbon dioxide from the air through stomata.

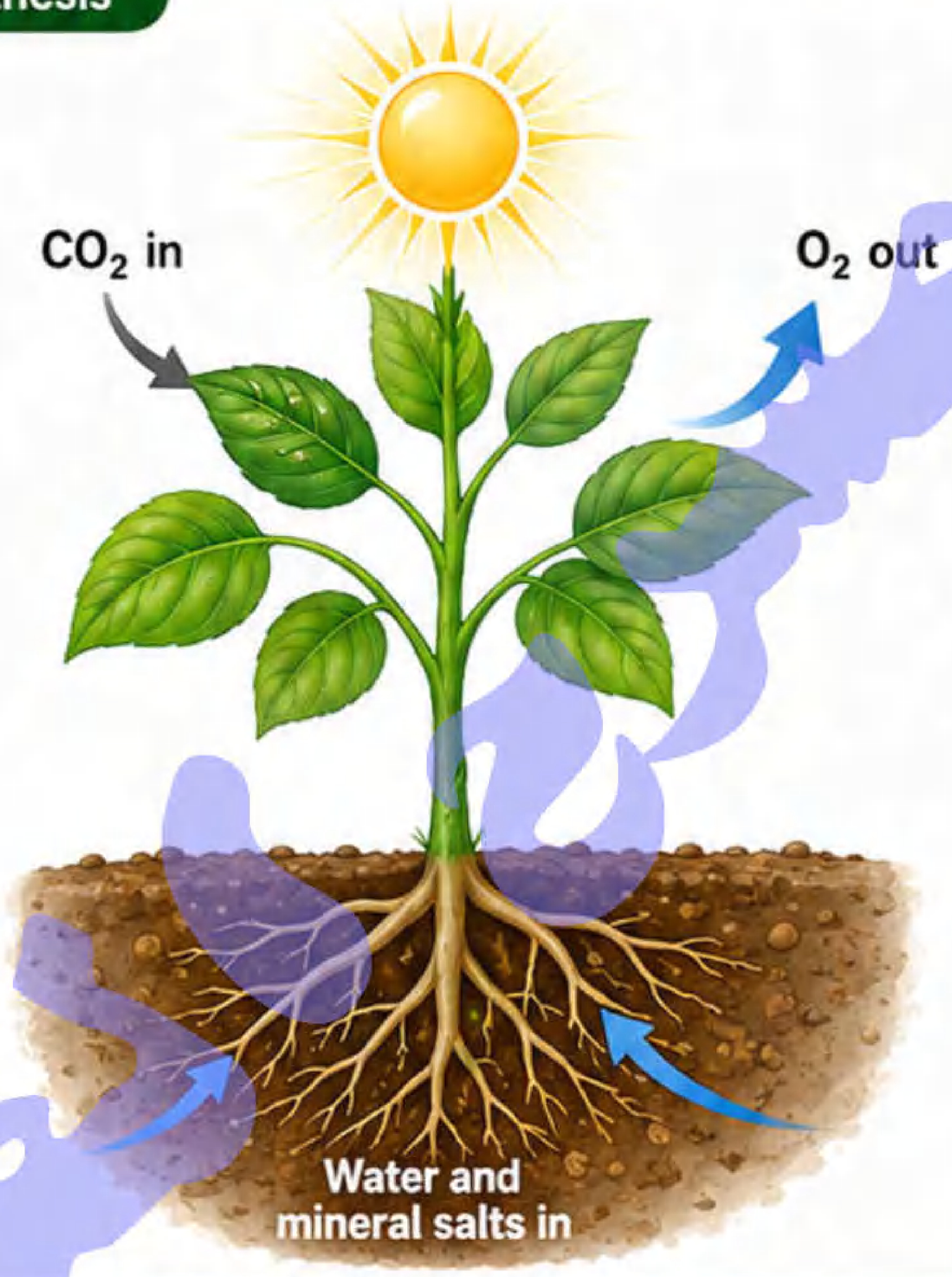
3

Chlorophyll in chloroplasts absorbs sunlight.

4

Using light energy, the plant converts water and carbon dioxide into glucose.

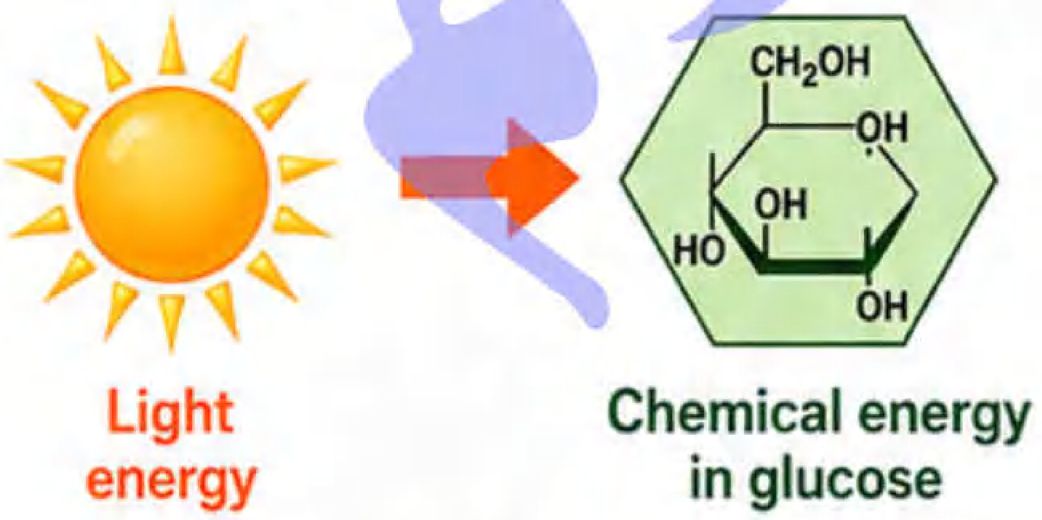
5

Oxygen is released to the air.


CO_2 in
O_2 out
Water and mineral salts in

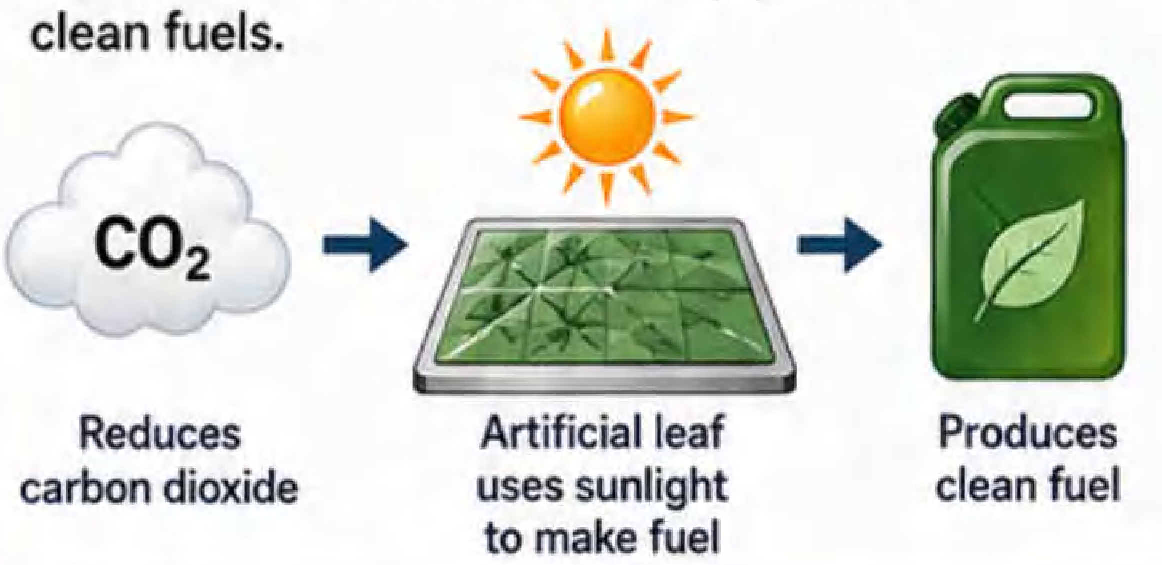
Matter and Energy in Photosynthesis

Photosynthesis transforms light energy into chemical energy stored in glucose.


CH_2OH
OH
OH
HO
OH
Light energy
Chemical energy in glucose

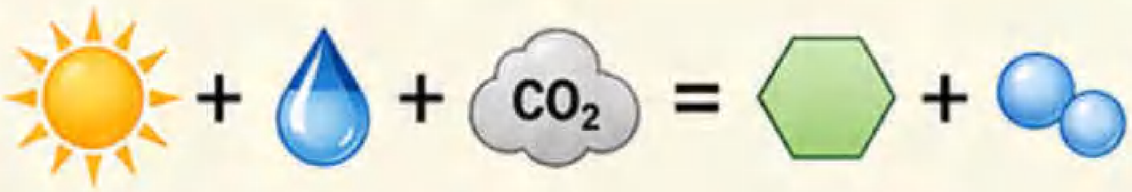
Artificial Photosynthesis

Scientists are creating "artificial leaves" that mimic photosynthesis. These technologies can reduce carbon dioxide and help produce clean fuels.


CO_2
Reduces carbon dioxide
Artificial leaf uses sunlight to make fuel
Produces clean fuel

KEY IDEA

Plants use sunlight, water and carbon dioxide to make glucose for energy and release oxygen.

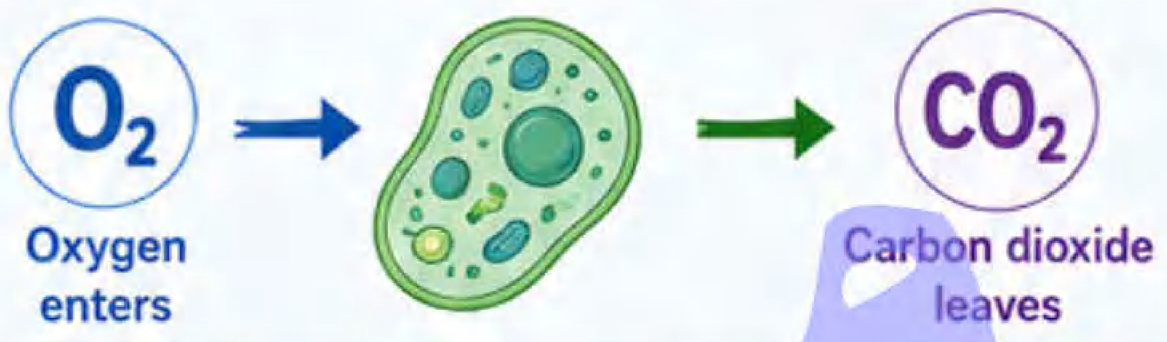


LESSON 1

Respiration in Living Organisms

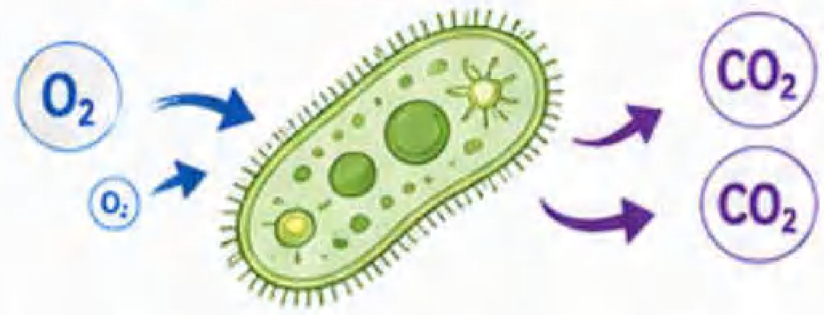
How living things obtain oxygen and release carbon dioxide.

Respiration is the process in which an organism obtains oxygen and releases carbon dioxide.



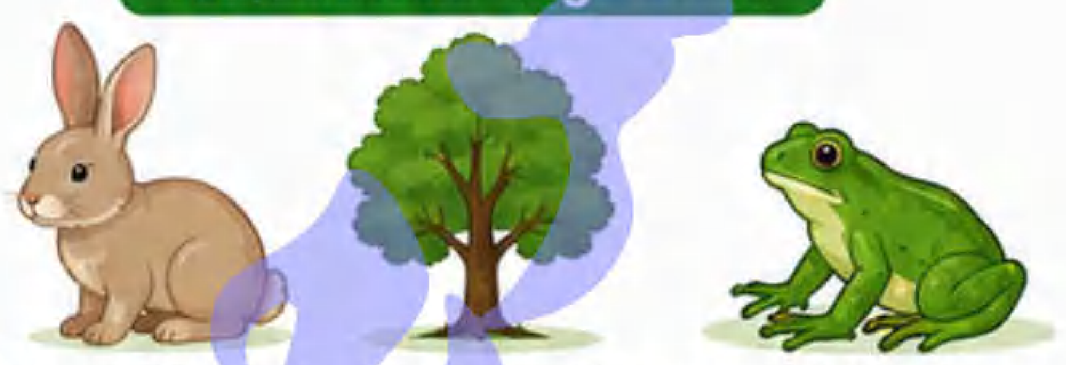
Respiration in Different Organisms

Unicellular Organisms



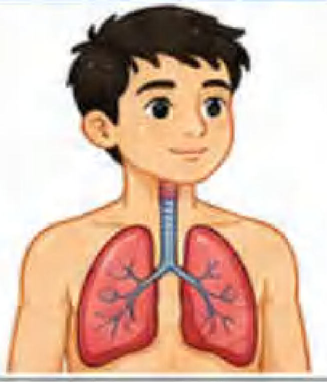
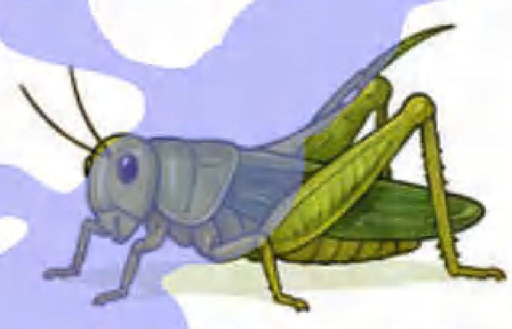
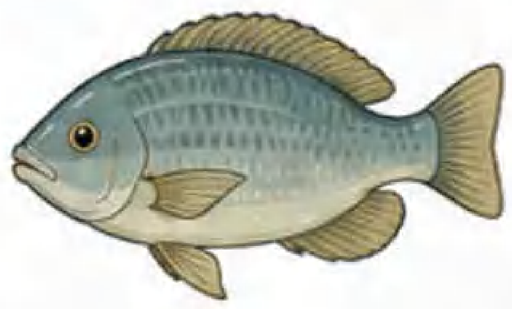
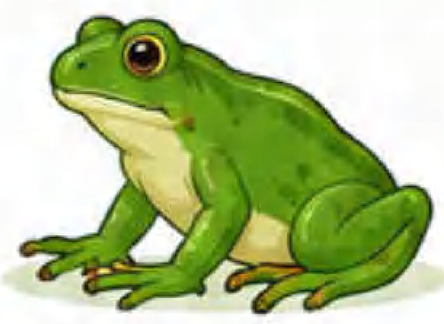
- Unicellular organisms obtain oxygen directly from the surrounding medium and release carbon dioxide directly to it.

Multicellular Organisms

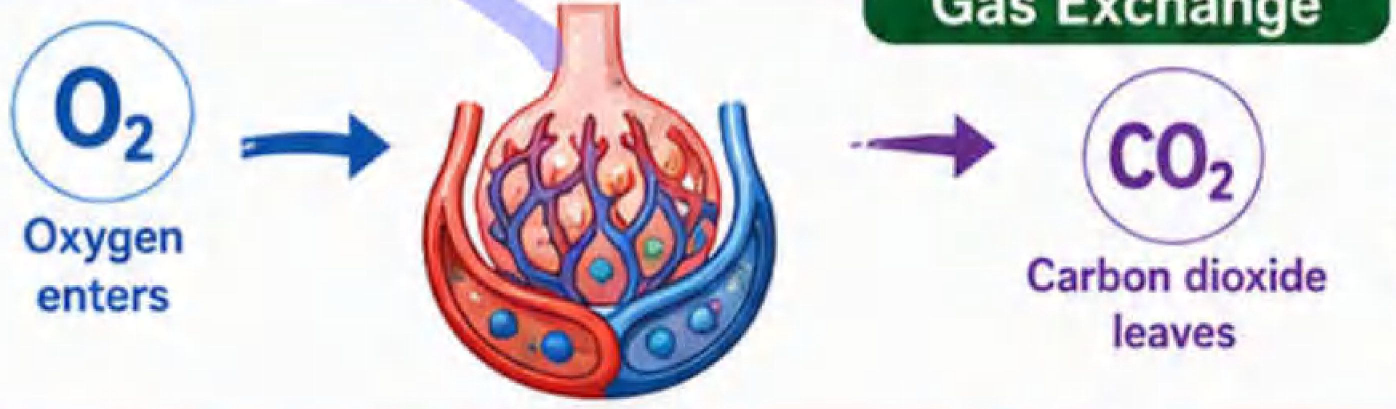


- Most multicellular organisms have specialized respiratory organs.
- Plants do not have a specialized respiratory system.

Respiratory Organs in Different Organisms

Mammals (example: human)	Insects (example: grasshopper)	Fish (example: tilapia)	Adult Amphibians (example: frog)
			
Respiratory organ: Lungs	Respiratory organ: Tracheal tubes	Respiratory organ: Gills	Respiratory organ: Lungs and skin
Medium: Air	Medium: Air	Medium: Water	Medium: Air and water

Gas Exchange



Oxygen from the medium moves into the organism's cells.

Carbon dioxide produced by cells moves out to the medium.

Respiration is essential for life because organisms need oxygen for their activities and must remove carbon dioxide.

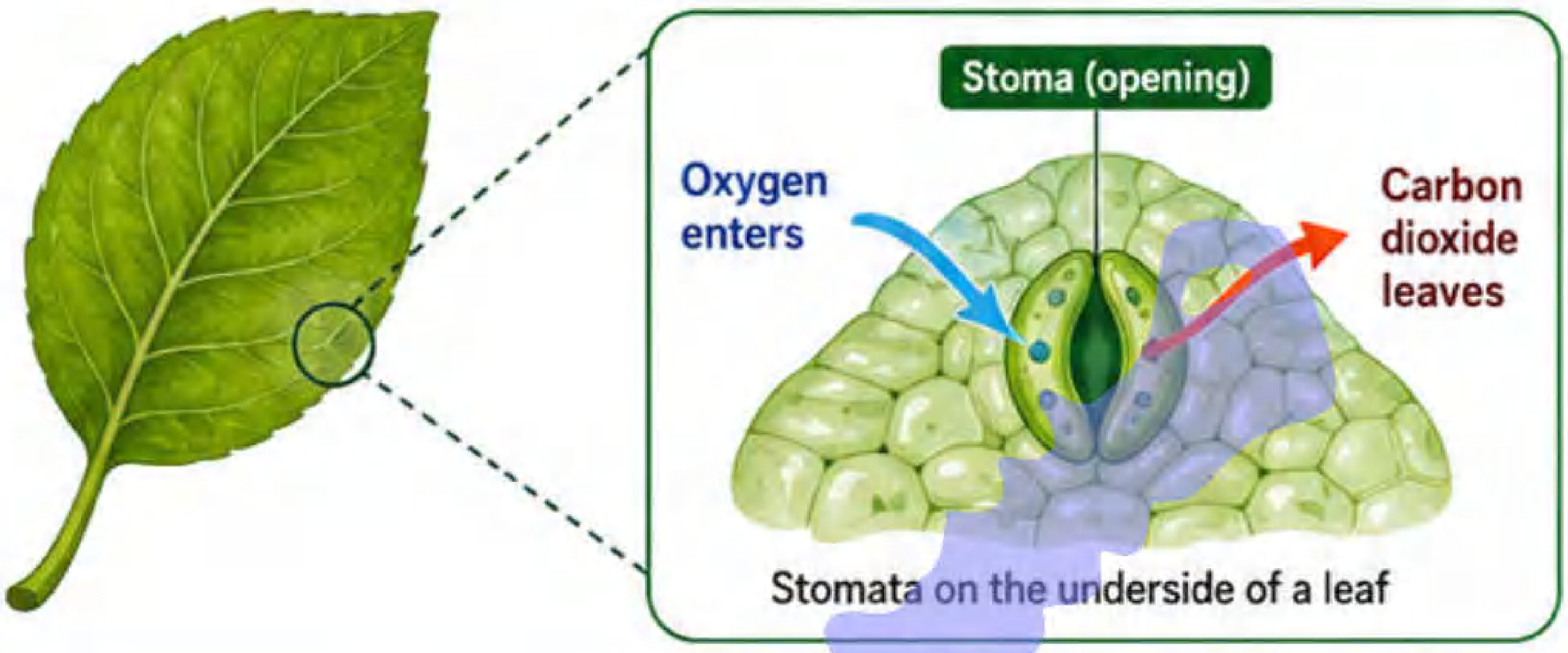
LESSON 1

Respiration in Plants & Cellular Respiration

Plants respire continuously, and cells release energy from glucose.

1 Respiration in Plants

- ✓ Plants do not have a specialized respiratory system.
- ✓ They obtain oxygen from the air through tiny openings called **stomata** on the leaves.
- ✓ Plants respire day and night.
- ✓ Photosynthesis and respiration are different processes.



Stomata on the underside of a leaf

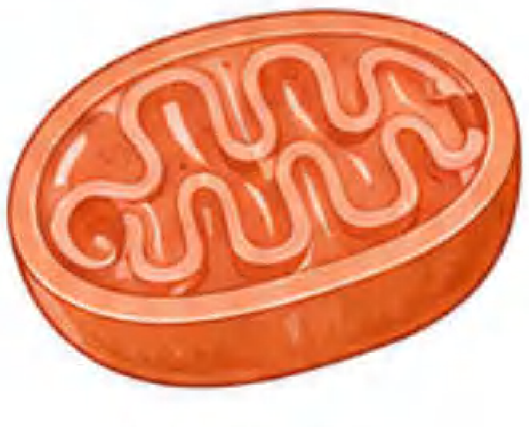
CORRECT THE MISTAKE

Mistake	Correct Idea
Plants stop respiring during the day.	Plants respire continuously day and night; during the day photosynthesis also occurs.

2 Cellular Respiration

Cellular respiration is the process in which glucose is broken down in the presence of oxygen to release energy for life activities.

Where it occurs	When it occurs	Outputs
In the mitochondria of plant cells.	Day and night	CO_2 Carbon dioxide Water Energy



Mitochondrion

The Process of Cellular Respiration

Glucose ($C_6H_{12}O_6$) + Oxygen (O_2) → Carbon dioxide (CO_2) + Water (H_2O) + Energy (usable for life activities)

3 In Plants: How These Processes Work Together

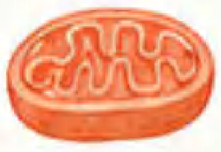
Photosynthesis (in chloroplasts)

Uses sunlight, water, and carbon dioxide to produce glucose and oxygen.

Carbon dioxide (CO_2) + Water + Sunlight → Glucose ($C_6H_{12}O_6$) + Oxygen (O_2)

Cellular Respiration (in mitochondria)

Uses glucose and oxygen to release energy, carbon dioxide, and water.



Glucose ($C_6H_{12}O_6$) + Oxygen (O_2) → Carbon dioxide (CO_2) + Water (H_2O) + Energy (usable for life activities)

KEY TAKEAWAY: Plants respire continuously, and cellular respiration provides the energy needed for all life activities, day and night.

LESSON 1

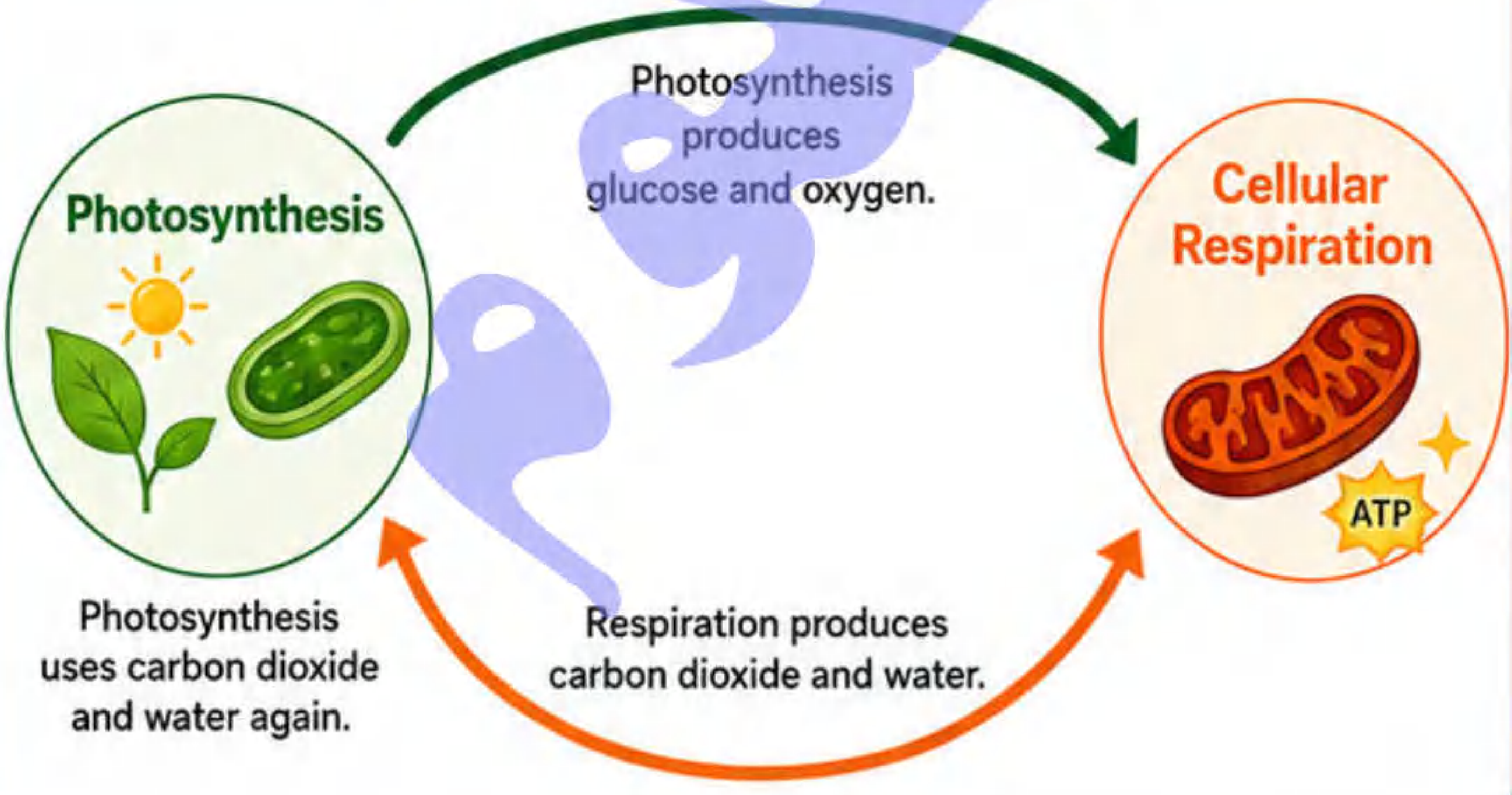
Photosynthesis vs Cellular Respiration

Photosynthesis and cellular respiration are related but different biological processes.

Main Differences

	Photosynthesis	Cellular Respiration
Where it occurs	occurs in chloroplasts	occurs in mitochondria
Organisms that perform it	performed by green plants, green algae, and some bacteria	performed by eukaryotic organisms
Main inputs	carbon dioxide, water, light energy	glucose and oxygen
Main outputs	glucose and oxygen	carbon dioxide, water, and energy
Energy transformation	transforms light energy into chemical energy	releases chemical energy for life activities
Main purpose	produces food	releases usable energy

How They Are Connected



Photosynthesis

Photosynthesis produces glucose and oxygen.

Cellular Respiration

Respiration produces carbon dioxide and water.

Photosynthesis uses carbon dioxide and water again.

In Plants

Both photosynthesis and cellular respiration occur in plants.

Photosynthesis occurs only **in light conditions during the day.**

Cellular respiration continues **day and night** to support all life activities.

Key Takeaway:
Photosynthesis captures and stores energy in glucose using light.
Cellular respiration breaks down glucose to release energy.
Together, they keep life and ecosystems in balance.

LESSON 1

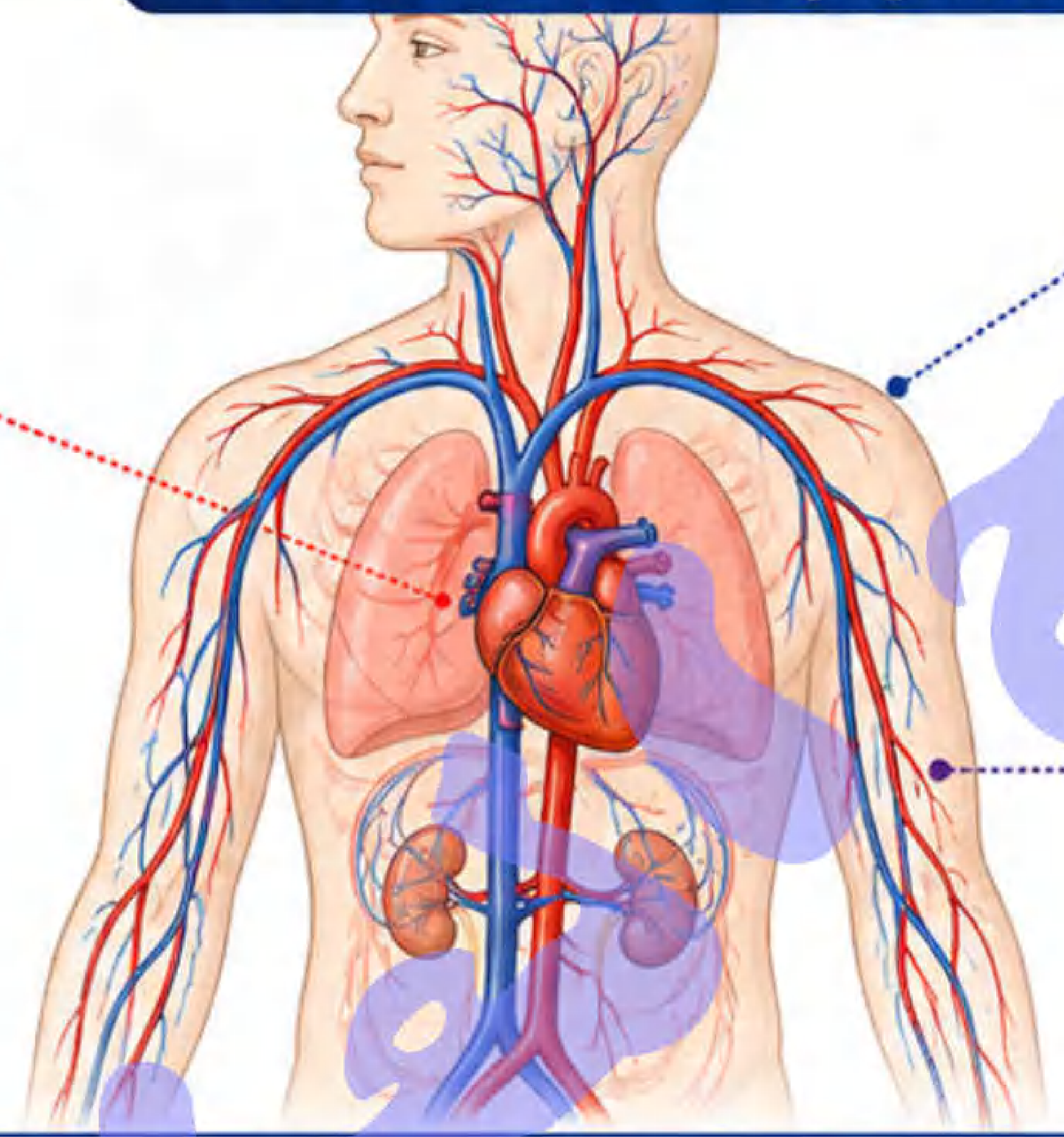
Transport in Humans

7/10

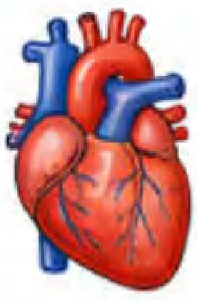
The circulatory system carries oxygen, nutrients, and wastes

Multicellular organisms have many cells. Cells need oxygen and nutrients and must get rid of wastes. To do this, they need specialized systems to transport substances. In humans, this system is the circulatory system.

The Human Circulatory System

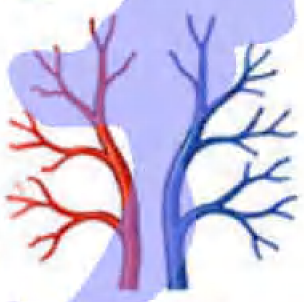


1 Heart



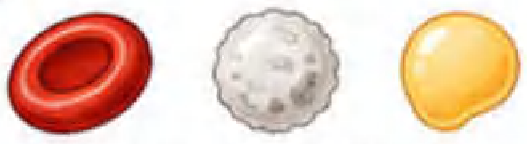
A muscular organ that pumps blood throughout the body.

2 Blood vessels



A network of tubes that carry blood to and from every part of the body.

3 Blood



A liquid tissue made of plasma, red cells, white cells, and platelets.

Blood Vessels

Arteries

Carry blood from the heart to body tissues.

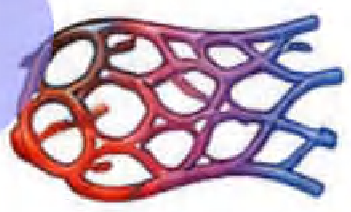
Usually thick-walled and under high pressure.

Veins

Carry blood from body tissues back to the heart.

Have valves to prevent backflow of blood.

Capillaries



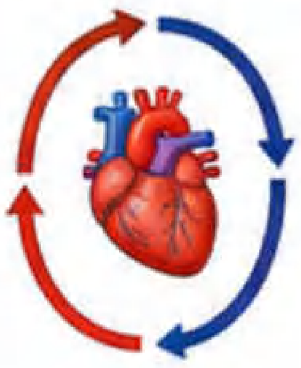
Tiny vessels where exchange occurs between blood and cells.

Walls are one cell thick for easy exchange.

What the Blood Transports

Digested food (nutrients) → Oxygen (O_2) → Carbon dioxide (CO_2) → Harmful wastes

Closed Circulation



Blood always stays inside blood vessels. It moves in a closed path from the heart, through vessels, and back to the heart.

Important Note

The digestive tract is not a closed path. Food enters at the mouth and leaves the body as waste.

Key Takeaway: The circulatory system is a closed transport system made of the heart, blood vessels, and blood. It transports oxygen, nutrients, and wastes to and from body cells, helping them stay alive and healthy.

LESSON 1

Transport in Plants

Xylem and phloem move water, minerals, and food through the plant.

The transport process in plants corresponds to transport in living organisms.
It is carried out by specialized tissues called xylem and phloem.

The Two Transport Tissues

Xylem

Carries water and mineral salts from roots to the rest of the plant.

- Water
- Mineral salts

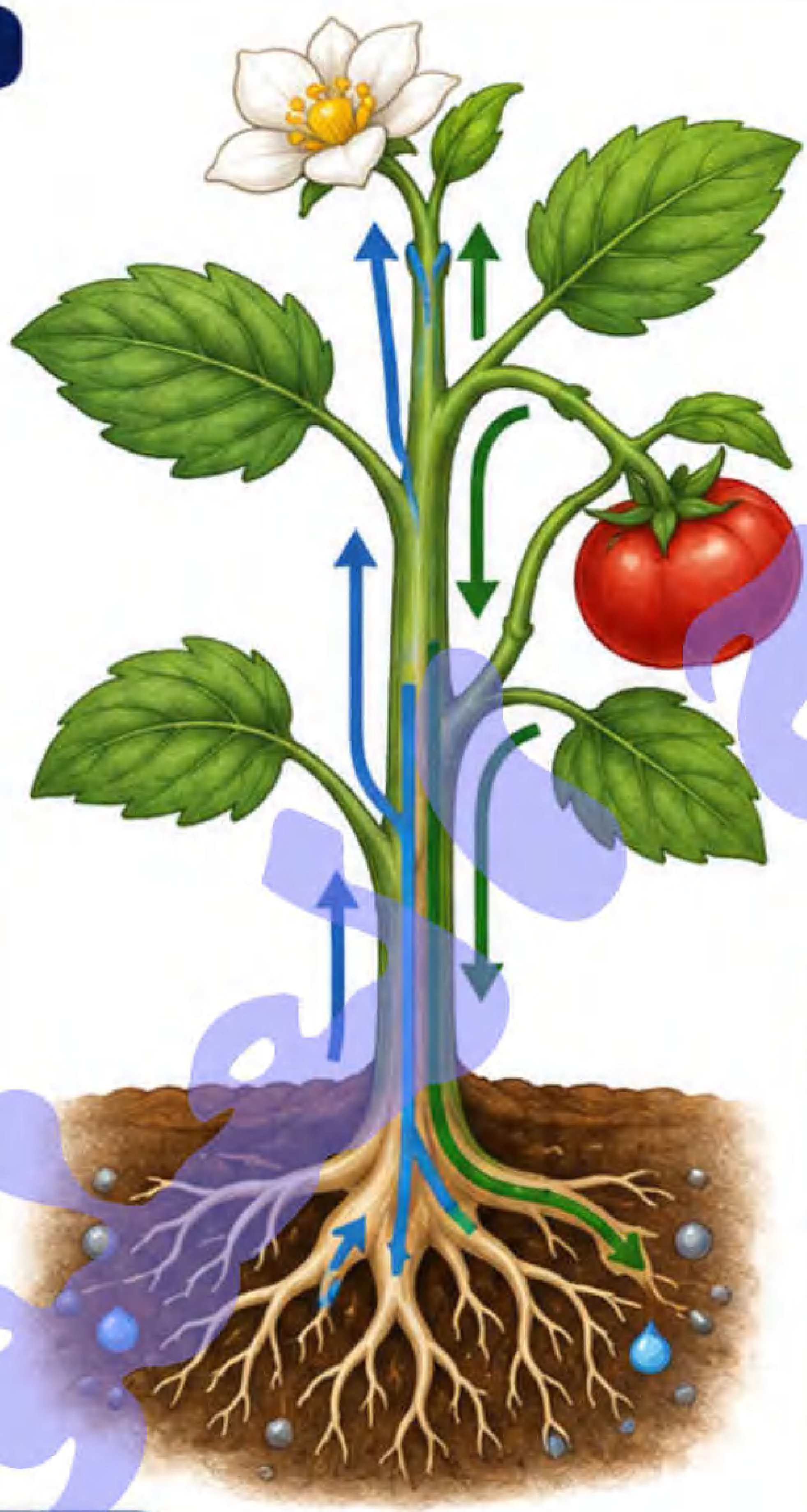
Direction: Upward only

Phloem

Carries food made in photosynthesis from leaves to the rest of the plant.

- Food (sugars)

Direction: Upward and downward



Xylem: water and minerals (upward)

Phloem: food (upward and downward)

Comparison Note

✓ **Xylem** transports upward only.

✓ **Phloem** transports upward and downward.

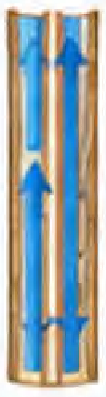
Roles of Plant Parts

	Roots Absorb water and mineral salts from the soil.
	Stem The pathway through which both water (xylem) and food (phloem) pass.
	Leaves Make food by photosynthesis and send it through phloem.
	Flowers / Fruits Receive both water/ minerals and food for growth and development.

Transport Path

1. Roots absorb water and mineral salts from the soil.

2. Xylem carries water and minerals upward through the stem.



3. Leaves make food during photosynthesis.

4. Phloem distributes food to all parts of the plant.

Water and minerals move up through xylem. Food moves to all parts through phloem. The stem is the main pathway where both are transported.

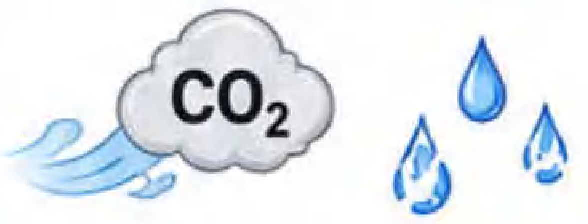
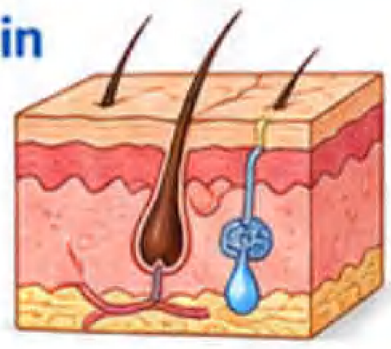
LESSON 1

Excretion in Humans and Plants

9/10

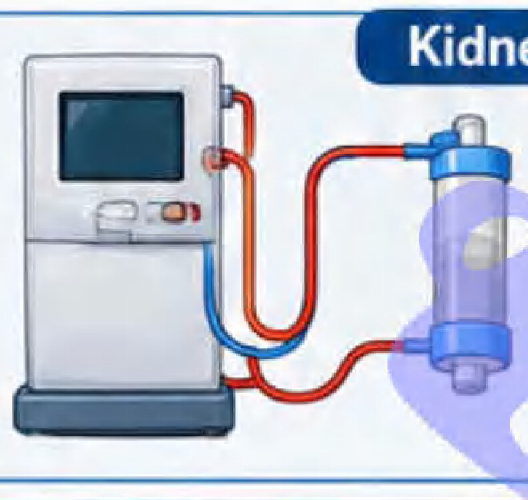
Excretion is the removal of harmful waste products and extra substances produced in cells.

Excretion in Humans

Organ	What It Removes
Lungs	 carbon dioxide and water vapor
Kidneys	urea, excess water, excess salts (in urine)
Skin 	water, salts, and a small amount of urea (in sweat)

! Feces are not considered excretory products in the strict scientific sense because they are undigested food residues, not cellular metabolic wastes.

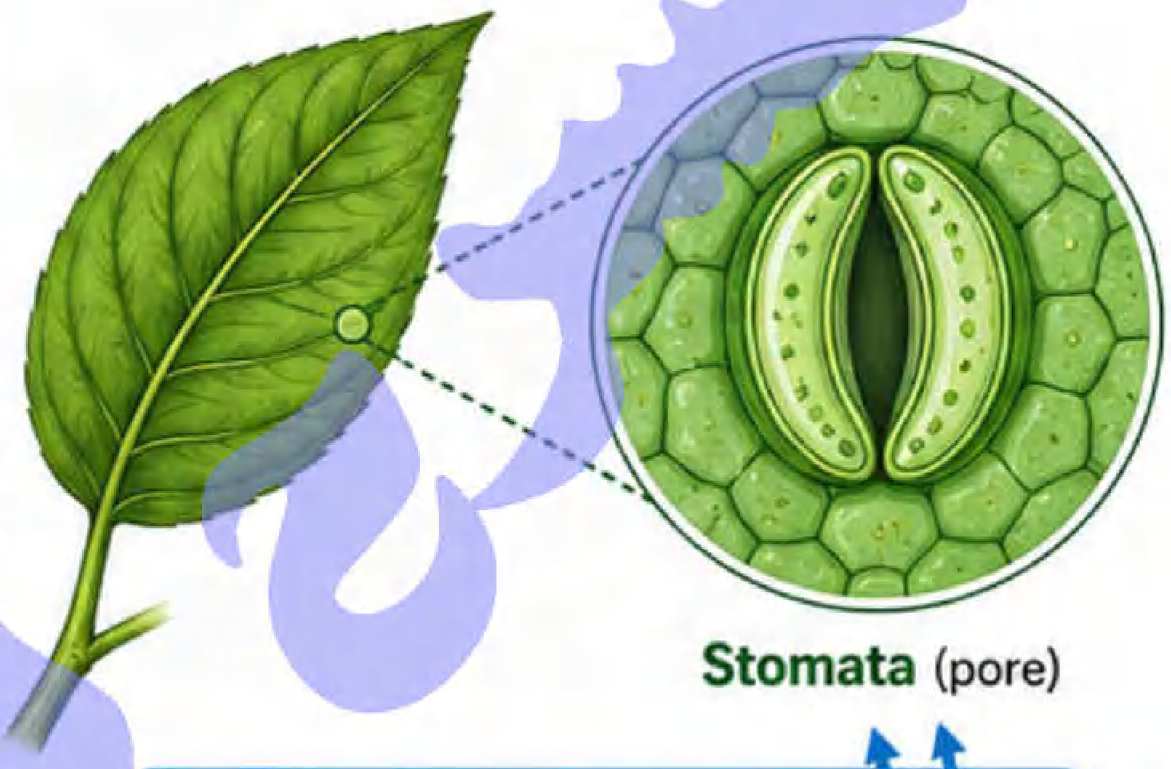
Kidney Dialysis



Dialysis is a medical treatment used when kidneys fail to properly clean the blood of excess water, urea, and salts.

Excretion in Plants

Plants remove excess substances through tiny pores called **stomata**, which are controlled by **guard cells**.



Stomata (pore)

Excess Water

Leaves release excess water vapor through stomata.

Carbon Dioxide

CO_2

Leaves release carbon dioxide, a waste gas of photosynthesis, through stomata.

Why Excretion Matters

- Keeps the internal environment balanced.
- Prevents the accumulation of toxic wastes.
- Helps cells work properly and stay healthy.
- Supports growth, energy, and overall well-being.

Key Takeaway: Excretion removes harmful wastes and extra substances to keep the body and plants healthy. Humans use organs like lungs, kidneys, and skin, while plants use stomata controlled by guard cells.

LESSON 1 Movement in Living Organisms

10/10

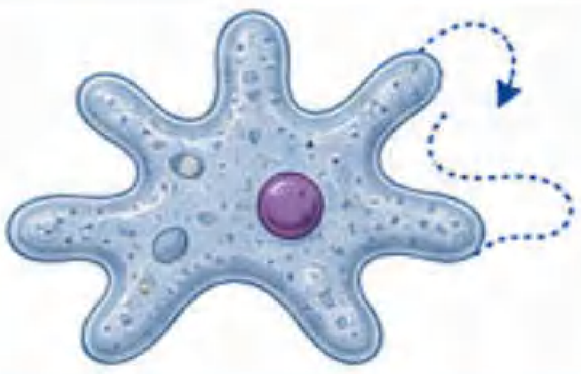
Movement is one of the essential life processes,
but it appears in different ways in different organisms.

Movement in Unicellular Eukaryotes

Single-celled eukaryotes move using special structures.

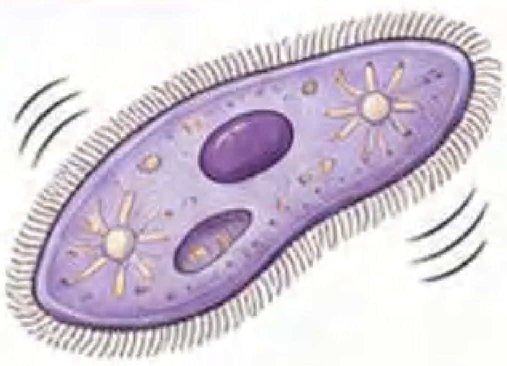
1 Amoeba

Moves using pseudopodia (false feet).



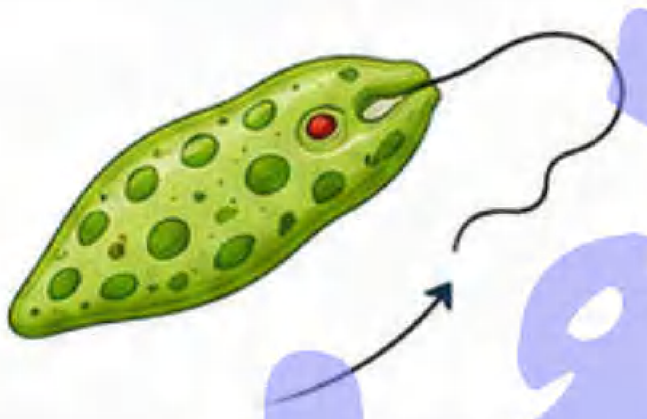
2 Paramecium

Moves using cilia (tiny hair-like structures).



3 Euglena

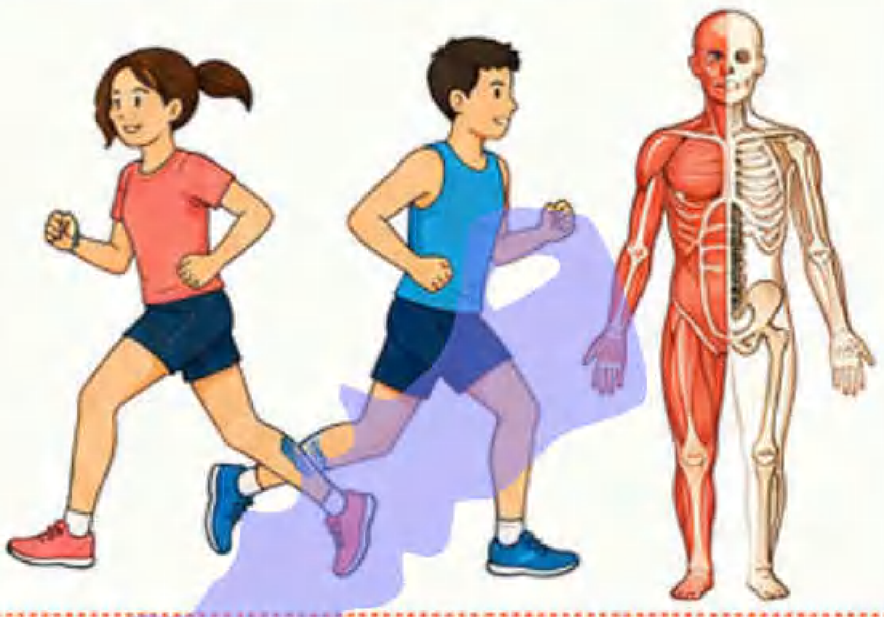
Moves using a flagellum (whip-like tail).



Movement in Multicellular Organisms

1 Humans

Movement is produced by the musculoskeletal system.

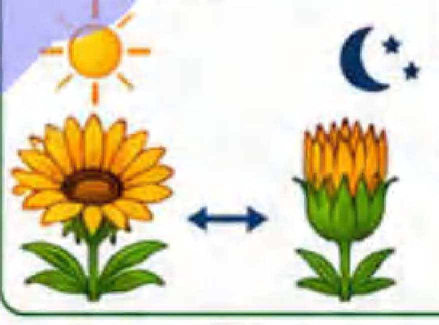


2 Plants

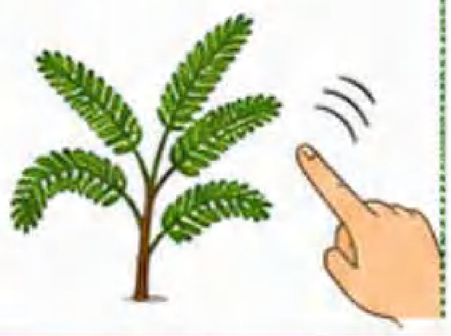
Plants do not move from place to place (locomotion), but limited movement appears in several forms.

Examples of Movement in Plants

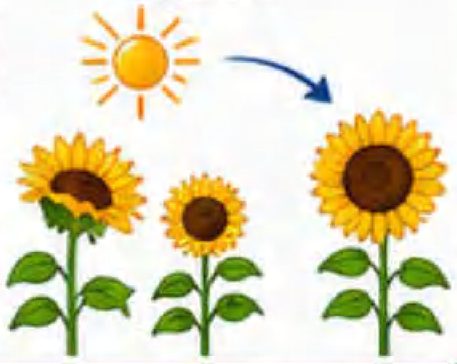
1. Gazania flowers open by day and close at night.



2. Sensitive plant leaves move when touched.



3. Sunflower flowers follow the direction of the sun.



Lesson Review Map

Essential Life Processes in Living Organisms

1. Nutrition
Autotrophic organisms make their own food. Heterotrophic organisms depend on other organisms for food.

2. Photosynthesis
Plants and some microorganisms use sunlight, water, and carbon dioxide to make glucose and release oxygen.

3. Respiration
Cellular respiration breaks down glucose in cells to release energy.

4. Transport in Humans and Plants
Humans use blood to transport substances. Plants use xylem and phloem to transport water, minerals, and food.

5. Excretion
Organisms remove waste products produced during life processes.

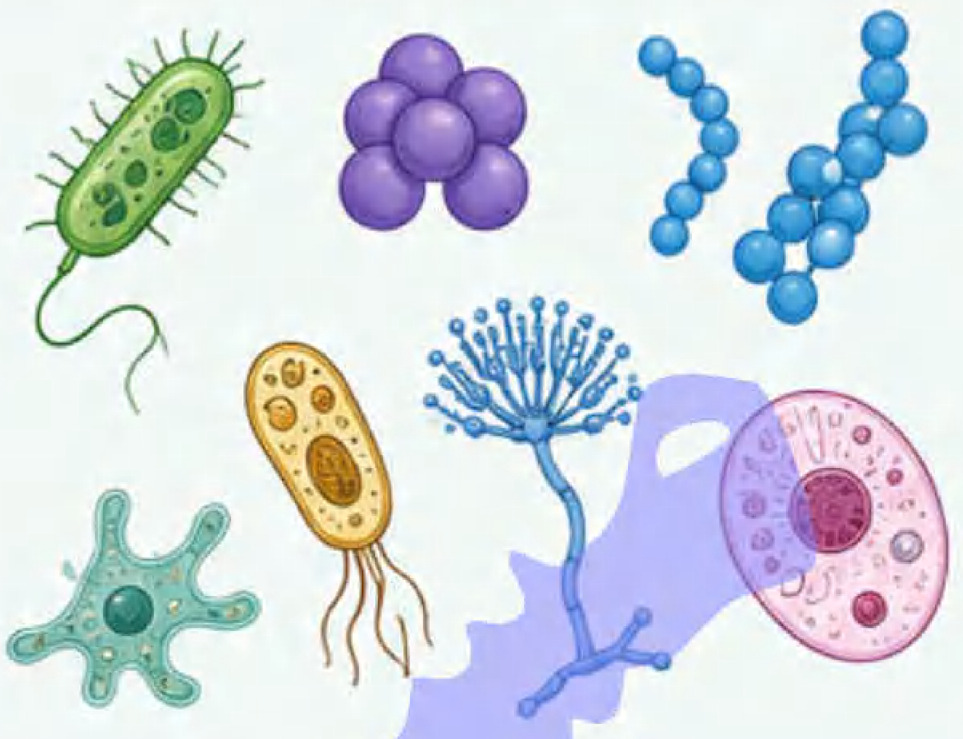
6. Movement
Organisms move in different ways, from single cells to plants and animals.

Living organisms share common life processes that keep them alive.
Although they differ in structure and mode of life, these processes unite all living things.

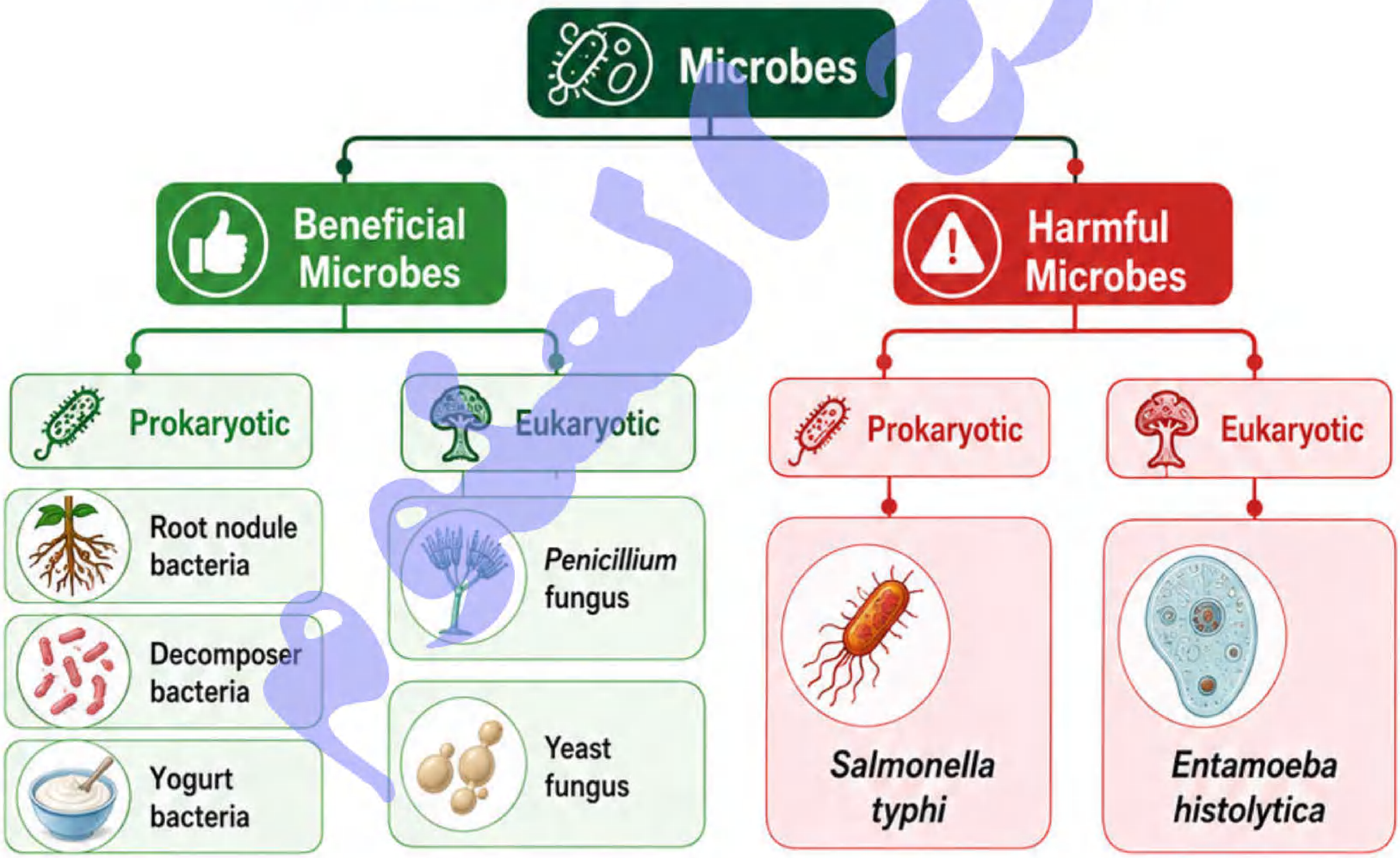
Microbes: Tiny Organisms Everywhere

Beneficial and harmful microbes

Microbes are tiny living organisms. Most cannot be seen with the naked eye. They are found around us and inside our bodies. Some are beneficial and some are harmful.



Classification of Some Microbes in This Lesson



- **Microbes**
  - **Beneficial Microbes**
    - Prokaryotic
      - Root nodule bacteria
      - Decomposer bacteria
      - Yogurt bacteria
    - Eukaryotic
      - *Penicillium* fungus
      - Yeast fungus
  - **Harmful Microbes**
    - Prokaryotic
      - *Salmonella typhi*
    - Eukaryotic
      - *Entamoeba histolytica*

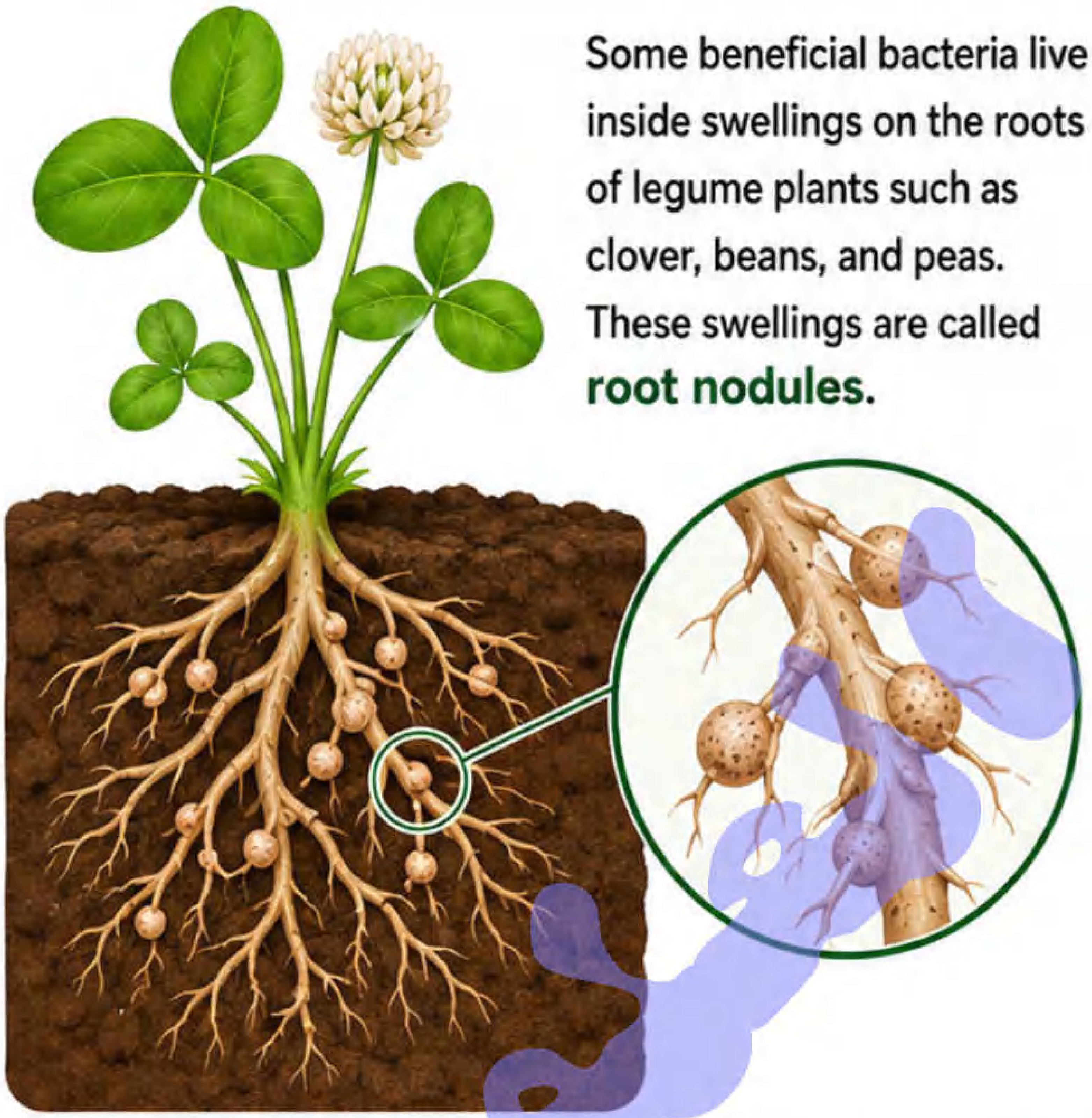
Viruses are not included here because they are not considered living organisms in this lesson. They cannot reproduce except inside living cells.

Root Nodule Bacteria

Beneficial prokaryotic microbes that help legume plants

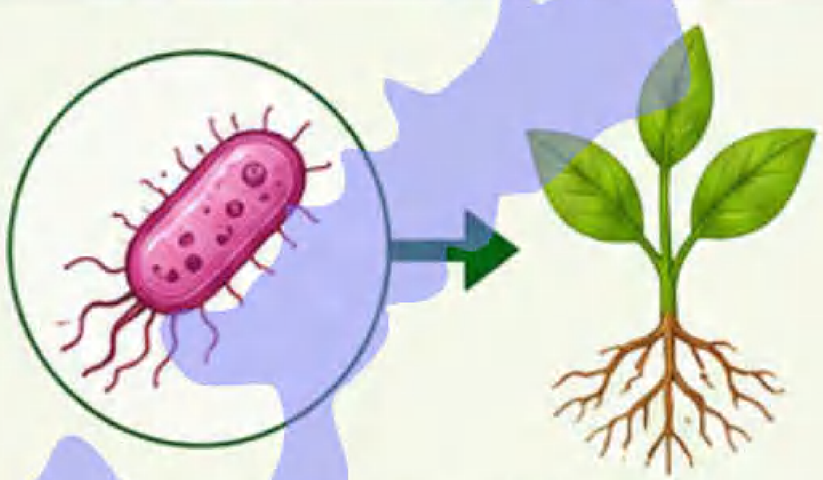
Legume plants need carbon, hydrogen and oxygen to form carbohydrates in photosynthesis, and they need nitrogen to build proteins used in growth and in their tissues.

C H O | N



Some beneficial bacteria live inside swellings on the roots of legume plants such as clover, beans, and peas. These swellings are called **root nodules.**

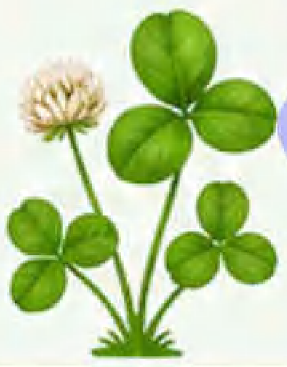
Why Are They Important?



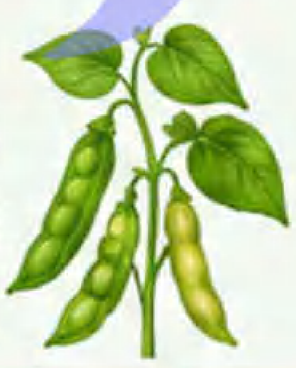
Root nodule bacteria help supply the plant with **nitrogen** in the form of **nitrogen compounds,** which the plant uses for growth.

Examples of Legume Plants

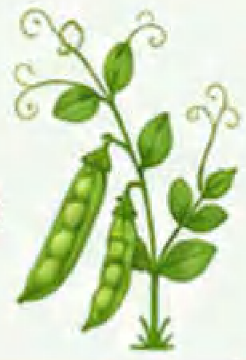
Clover



Bean plant



Pea plant



Key Terms

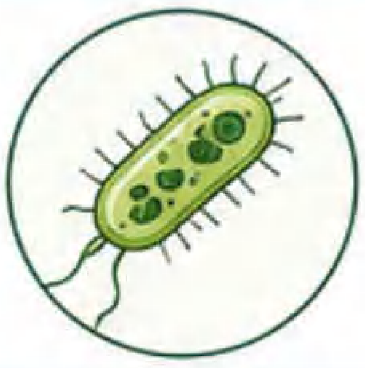
Root nodule bacteria: beneficial bacteria living inside root nodules of legume plants and supplying nitrogen compounds.

Root nodules: swellings on legume roots that contain the beneficial bacteria.

Key Idea: Root nodule bacteria live in root nodules of legume plants and support plant growth by helping provide usable nitrogen compounds.

Decomposer Bacteria & Soil Fertility

Beneficial bacteria that enrich the soil

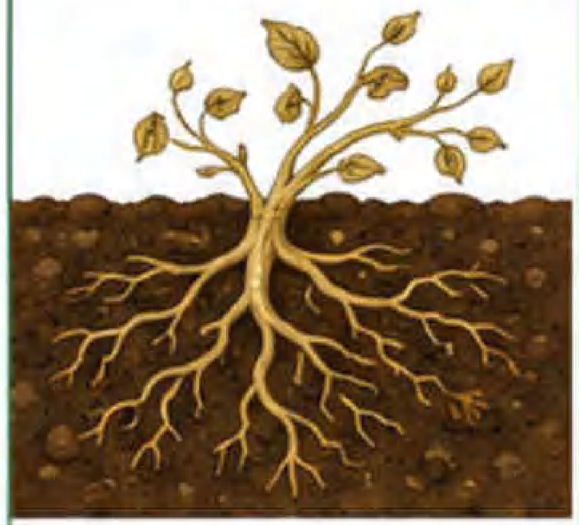


Decomposer bacteria are beneficial prokaryotic microbes.

Importance of Decomposer Bacteria

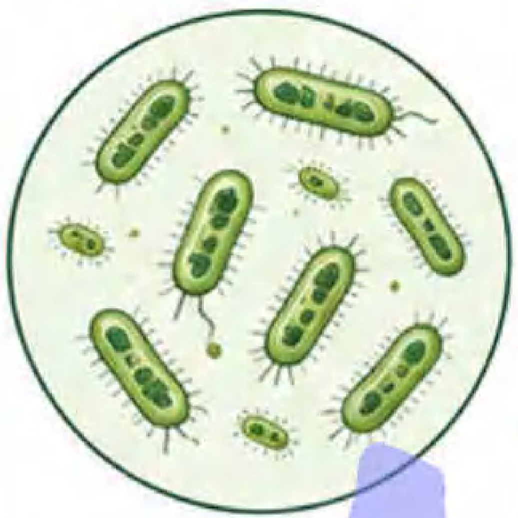
Decomposer bacteria decompose the remains and roots of legume plants into soluble nitrogen compounds in the soil.

1 Plant remains and roots in soil



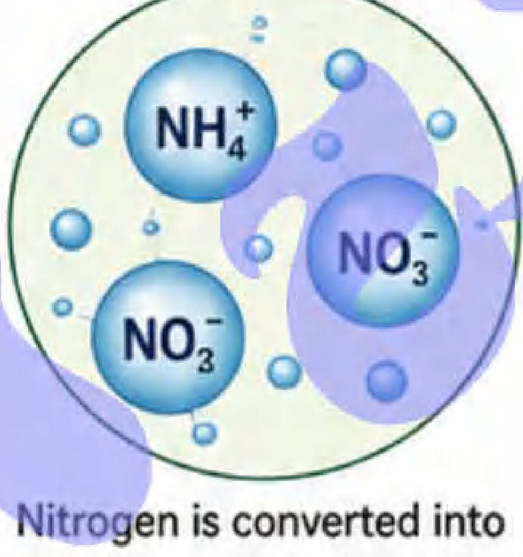
After harvest, legume plants and their roots remain in the soil.

2 Decomposer bacteria act



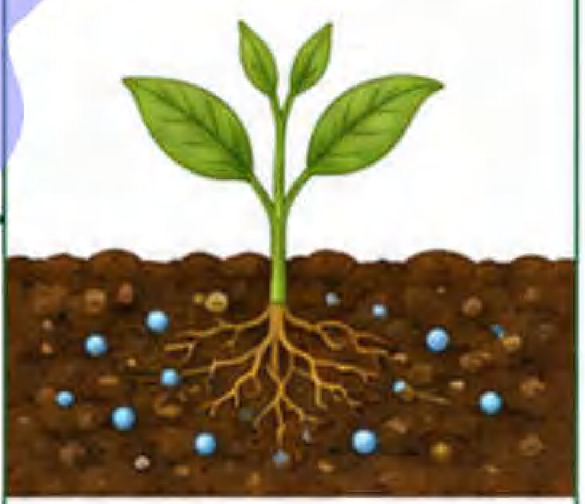
Decomposer bacteria break down the organic matter.

3 Soluble nitrogen compounds form



Nitrogen is converted into soluble compounds such as ammonium (NH_4^+) and nitrate (NO_3^-) in the soil.

4 Soil fertility increases



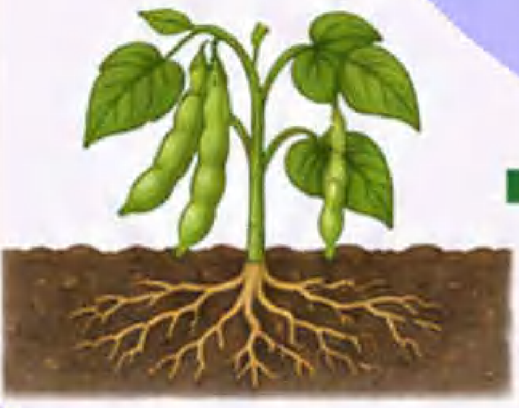
Plants can absorb these compounds, making the soil more fertile.

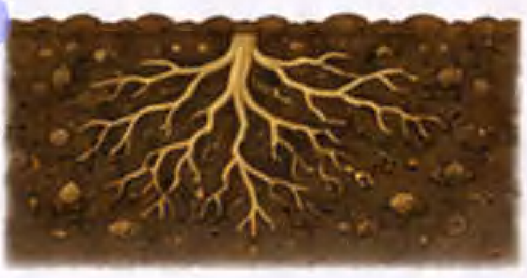
Outcomes

- increase soil fertility
- help maintain the cycle of elements in nature

Application / Reasoning

After harvesting legume plants (such as beans), farmers may leave their roots in the soil.

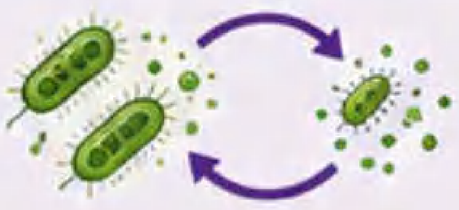




It is useful to grow a crop such as cotton after beans because the soil becomes rich in nitrogen compounds needed by the next plant.

Key Idea

Decomposer bacteria improve agricultural soil by returning usable nitrogen compounds to it.



Yogurt Bacteria & Fermentation

How beneficial bacteria turn milk into yogurt

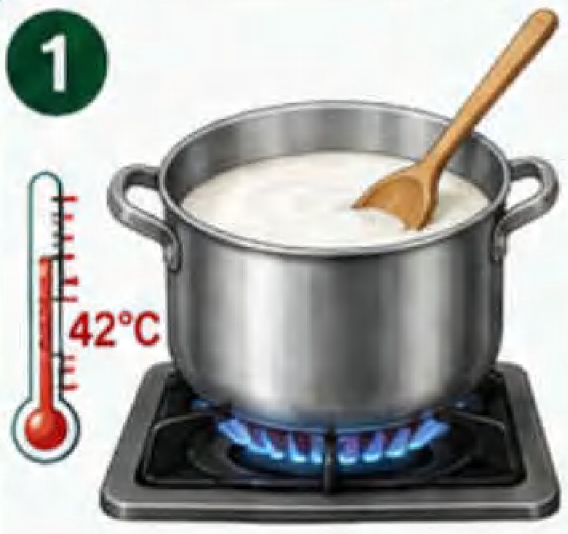
Yogurt is an important food. It is rich in protein needed for body building and muscle growth, and calcium needed for healthy bones and teeth.

Protein for body building and muscle growth

Calcium for healthy bones and teeth

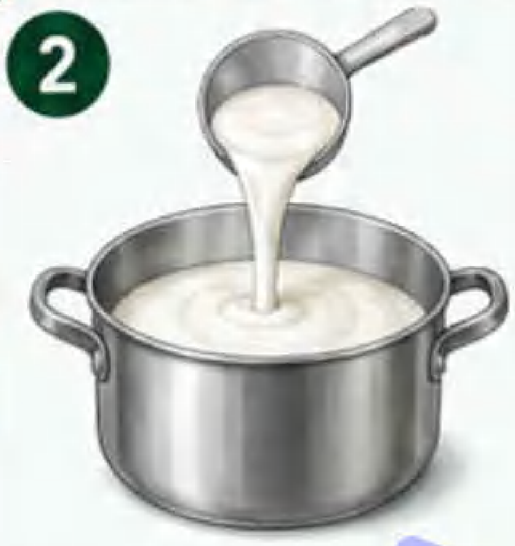
Steps of Making Yogurt

1



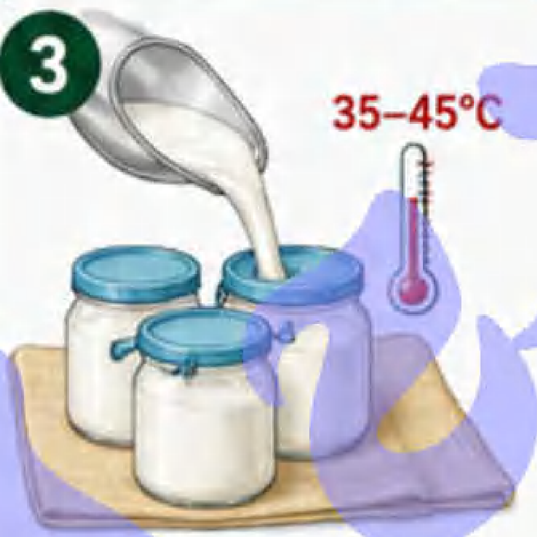
Heat milk while stirring until it is boiled, then let it cool until it is warm, about 42°C.

2



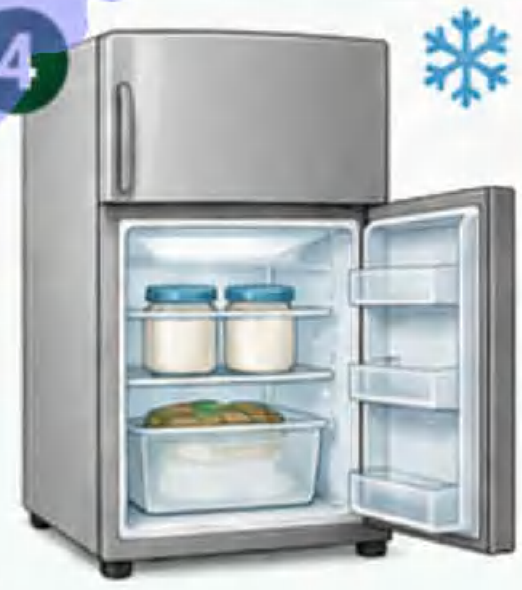
Add half a cup of prepared yogurt starter to the milk because it contains yogurt bacteria.

3



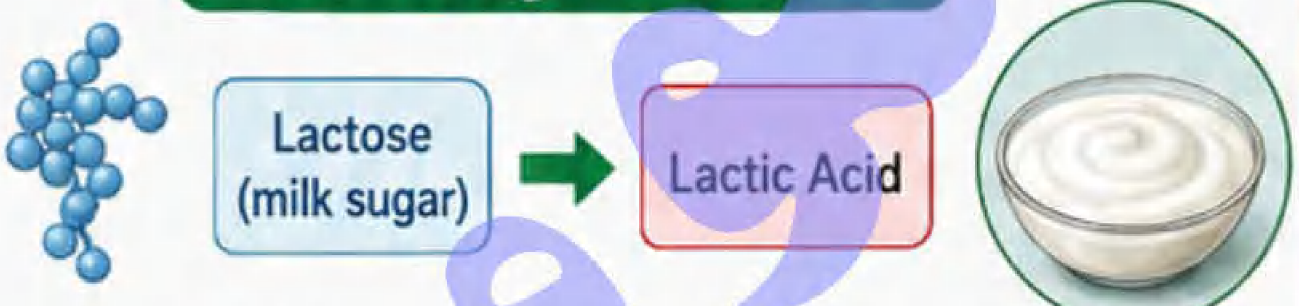
Pour the milk into containers and leave it in a warm place around 35–45°C for about 4–5 hours so bacterial fermentation can occur.

4



Transfer the containers to the refrigerator to stop continuous bacterial activity.

Role of Yogurt Bacteria



Yogurt bacteria convert lactose, the milk sugar, into lactic acid. Lactic acid gives yogurt its special sour taste and thick, creamy texture.

Fermentation

Fermentation is the biological process in which yogurt bacteria convert lactose into lactic acid. If yogurt is kept without refrigeration after preparation, bacterial activity continues, more lactic acid forms, acidity increases, and the taste changes.

Life Application

Pickled olives are made in a salty solution. Adding a spoon of sugar helps beneficial bacteria, which convert the sugar into lactic acid that improves the flavor.

Key Idea

Beneficial bacteria are used in food production. They transform important ingredients and improve taste, texture, and nutritional value.

D.M.RAZK
موقع الدكتور محمد رزق معلم الكيمياء التعليمي

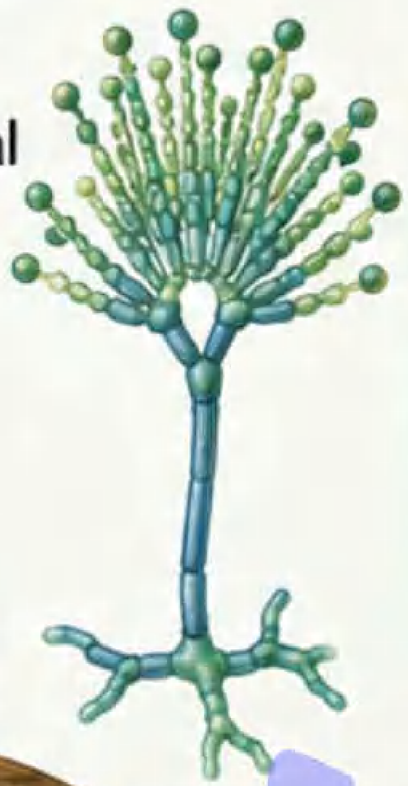
Beneficial Fungi: *Penicillium*

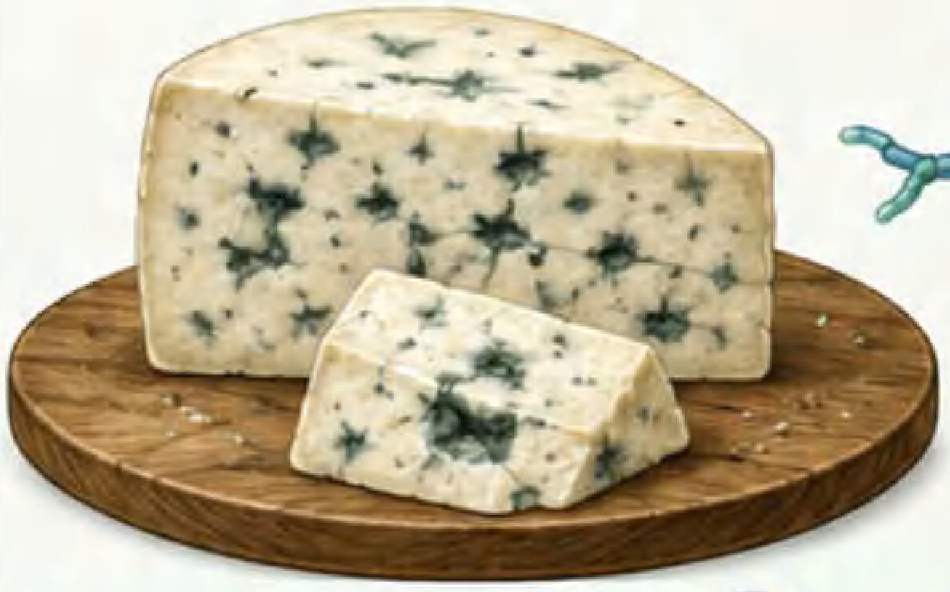
Useful eukaryotic microbes in food and medicine

Beneficial fungi are useful eukaryotic microbes.

Ⓐ *Penicillium roqueforti*

This fungus is used in making **Roquefort cheese**. The special flavor and characteristic appearance of the cheese are due to this fungus.

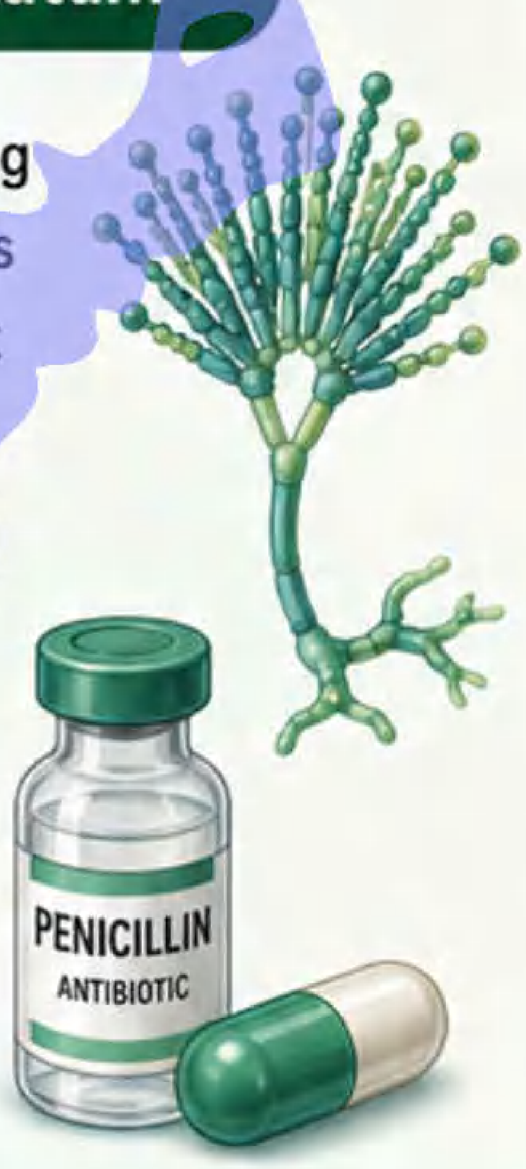




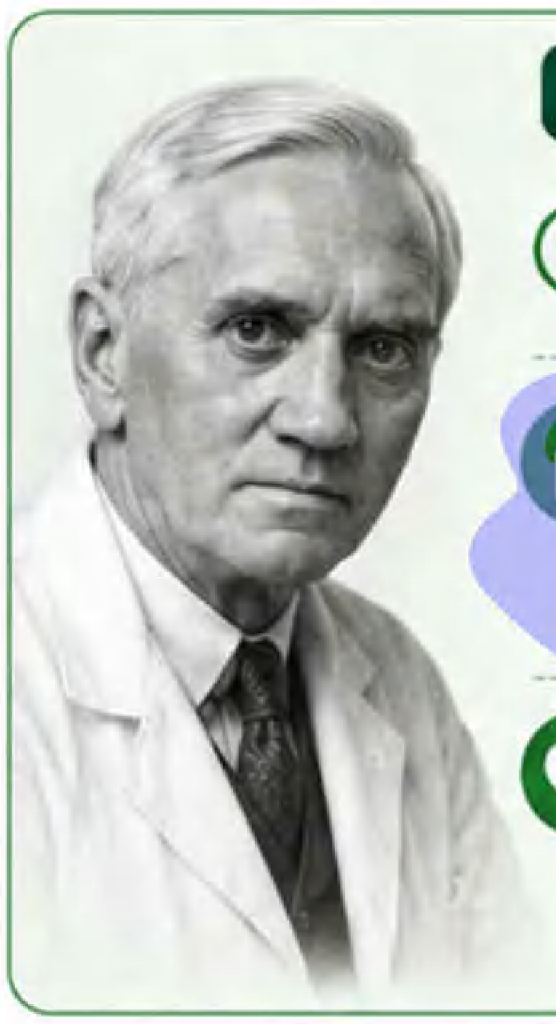
Ⓑ *Penicillium notatum*

In **1928**, Alexander Fleming discovered that this fungus produced a substance that stopped the growth of some bacteria.

The extracted antibiotic is **penicillin**, which is used to fight bacterial diseases such as diphtheria and tonsillitis.

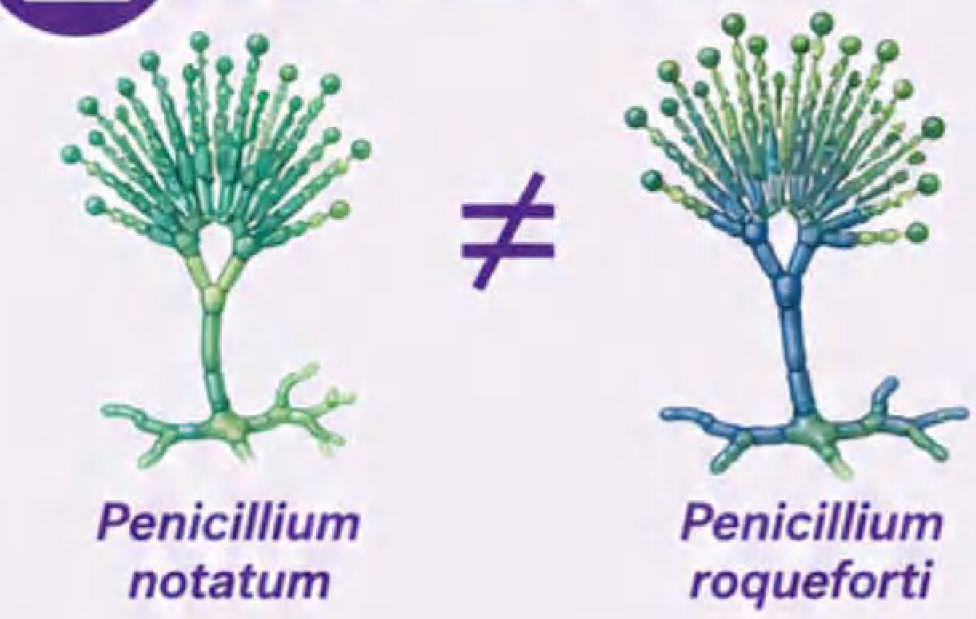


Alexander Fleming



- Scottish scientist who discovered penicillin in **1928**.
- Penicillin was the first antibiotic and revolutionized the treatment of bacterial infections.
- His discovery has saved millions of lives and laid the foundation for modern antibiotics.

Did You Know?



Differences in structure between ***Penicillium notatum*** and ***Penicillium roqueforti*** lead to differences in function.

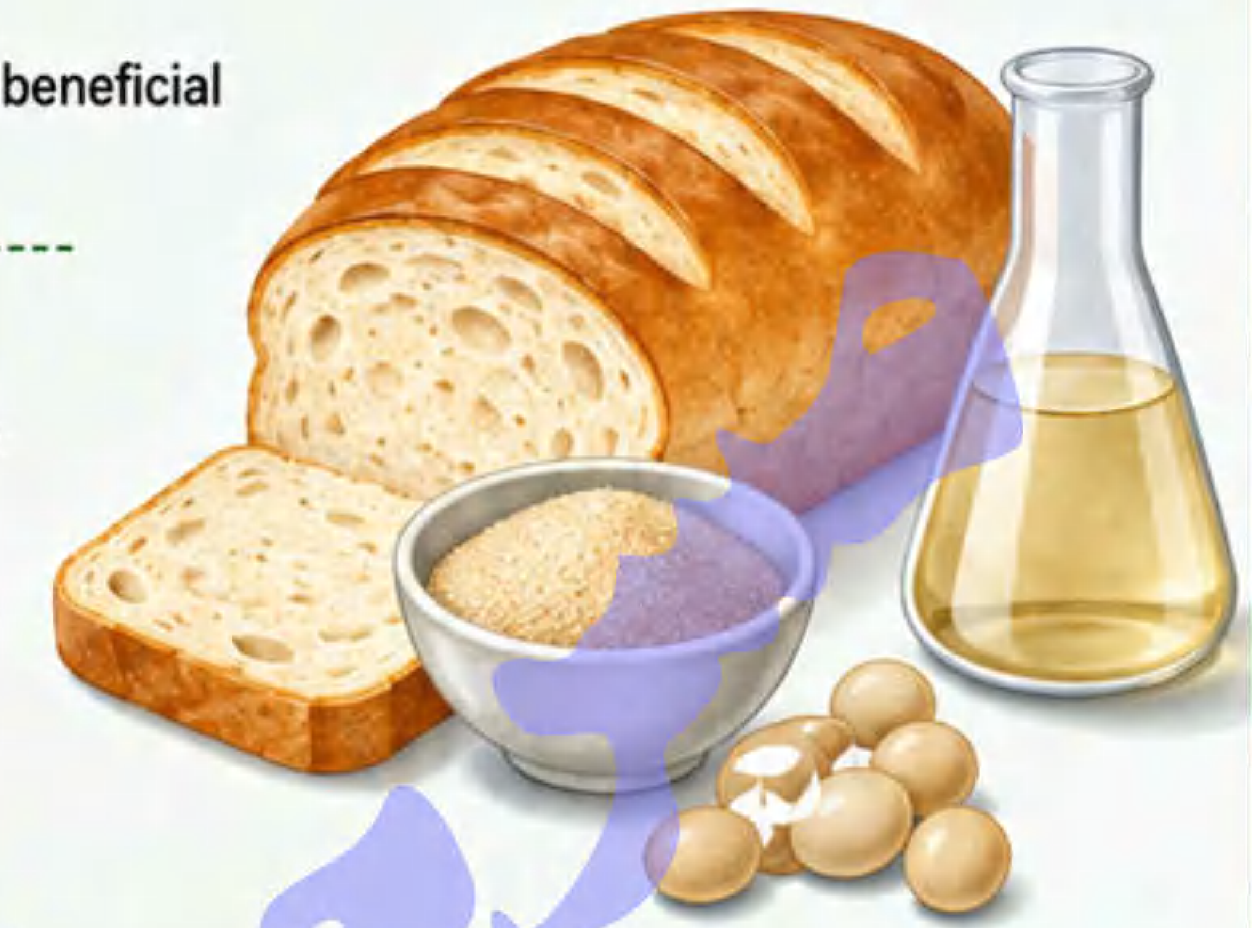
KEY IDEA Some fungi are beneficial to humans in both food industries and medicine.

Yeast & Harmful Microbes

A beneficial fungus and the ways harmful microbes enter the body

Yeast Fungus

Yeast is a single-celled fungus. It is a beneficial eukaryotic microbe.



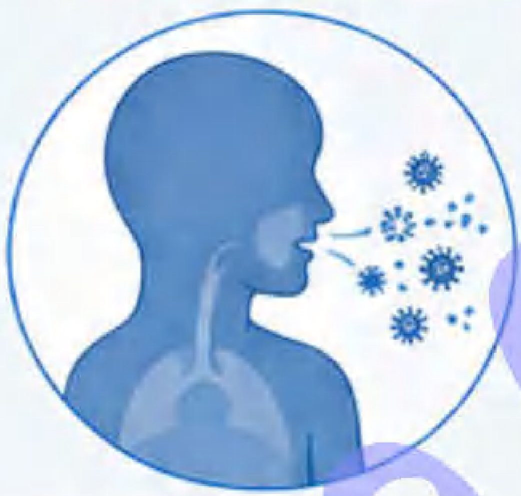
Uses and Importance

- ✓ Used in making bread. Yeast makes the dough rise by producing carbon dioxide.
- ✓ Used in making ethyl alcohol (alcoholic beverages and bioethanol).
- ✓ Considered a source of vitamin B complex.
- ✓ Rich in antioxidant compounds that help protect cells from damage.

How Harmful Microbes Enter the Human Body

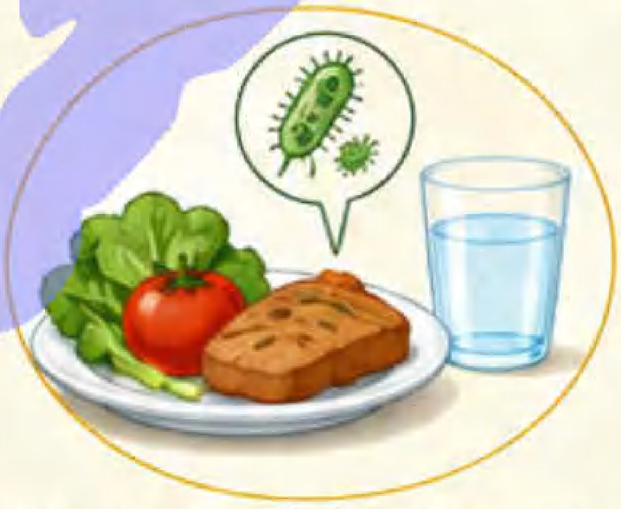
Harmful microbes can enter the body through the following routes:

1. Breathing



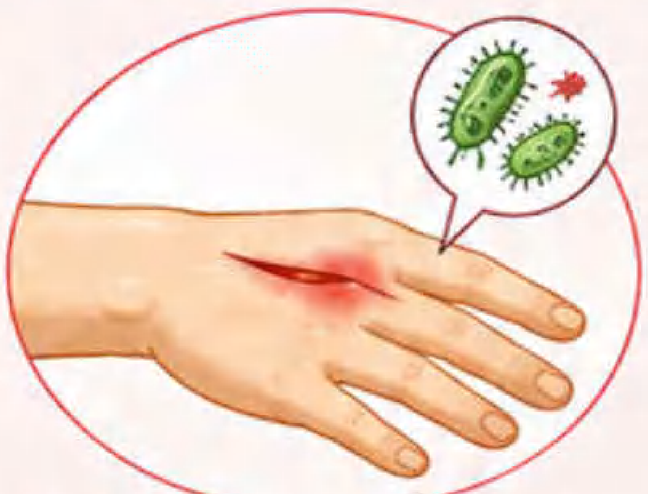
Microbes in the air can be inhaled through the nose or mouth and reach the lungs.

2. Eating Contaminated Food



Microbes on food or in water can enter through the mouth and reach the stomach and intestines.

3. Through Skin (Wounds or Burns)



Microbes can penetrate broken skin and enter the blood through wounds or burns.

Microbes are all around us. Their effect depends on their type and how they interact with our bodies.

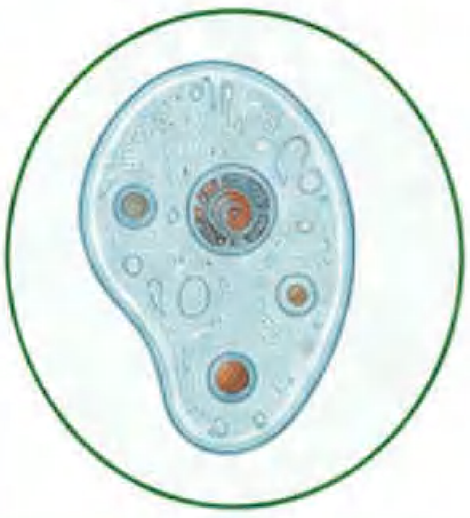
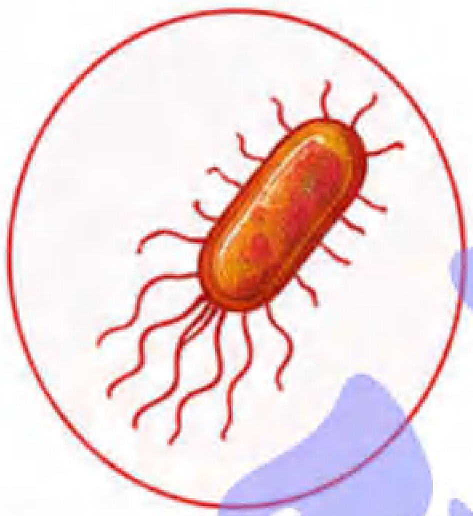
KEY IDEA

Yeast is a useful microbe that helps in food and industry and provides nutrients. However, some microbes are harmful and can cause disease after entering the body.

Food-Borne Diseases: Dysentery vs Typhoid

Two harmful microbes associated with contaminated food

These are examples of diseases that result from eating food or drinking water contaminated with harmful microbes.

Amoebic Dysentery	Typhoid
 **Causative microbe:** *Entamoeba histolytica*, a unicellular protozoan and a eukaryotic parasite.	 **Causative microbe:** *Salmonella typhi*, a prokaryotic bacterium.
Disease type: parasitic disease	**Disease type:** bacterial disease
Transmission: eating food contaminated with the microbe	**Transmission:** eating food or drinking water contaminated with the microbe
Habitat in the patient: large intestine	**Habitat in the patient:** digestive canal
Symptoms: repeated diarrhea mixed with blood, stomach pain, loss of appetite, weight loss, continuous tiredness	**Symptoms:** severe fever that may reach 40°C, headache, feeling tired, swelling and pain in the stomach and muscles
Treatment: antiparasitic drugs	**Treatment:** antibiotics

Key Takeaway

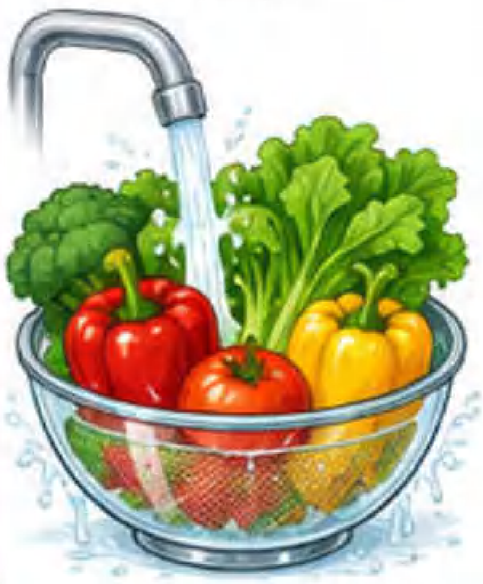
Different harmful microbes can cause different diseases, but contamination and poor hygiene are major factors.

Preventing Microbial Diseases

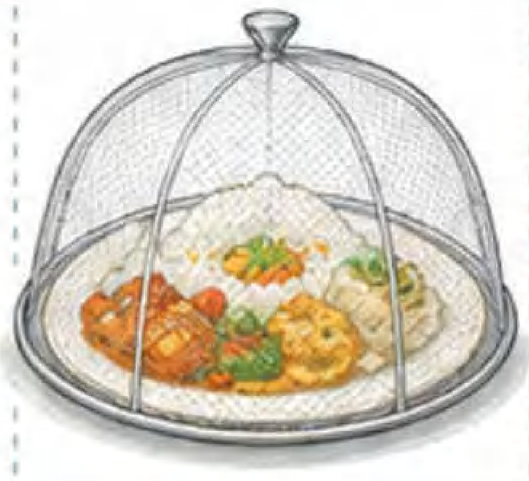
Healthy habits for protection, plus a final lesson review

Healthy Habits for Prevention

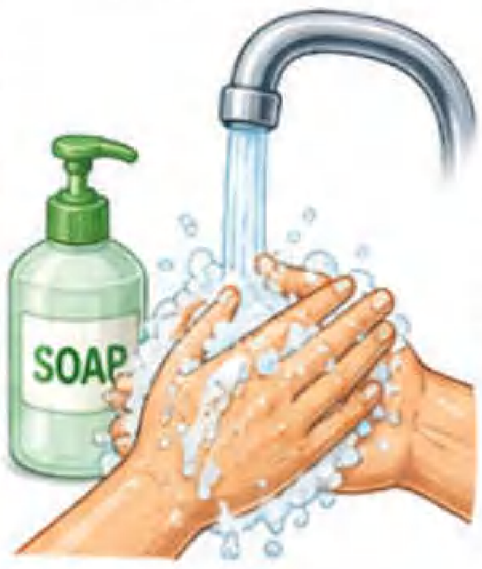
1. Wash vegetables and fruits well before eating them.



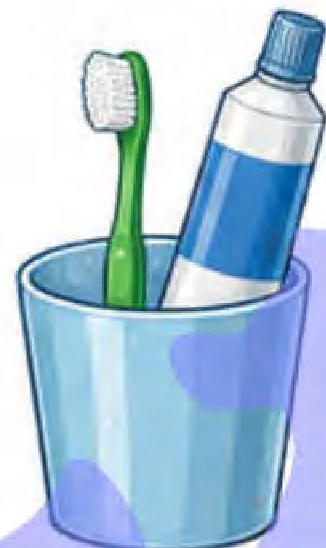
2. Do not leave food uncovered to protect it from contamination.



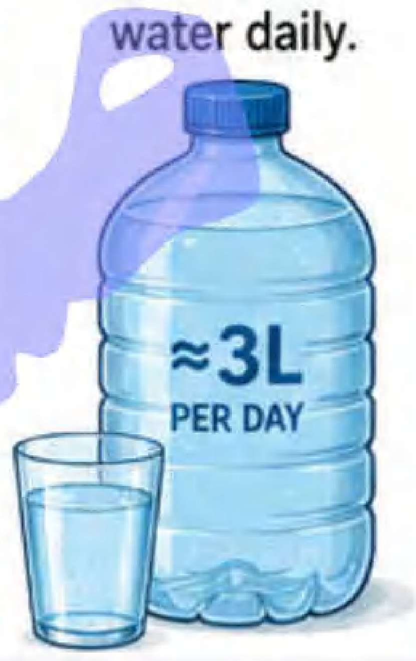
3. Wash hands before eating and after using the bathroom.



4. Brush teeth with a personal toothbrush after meals.

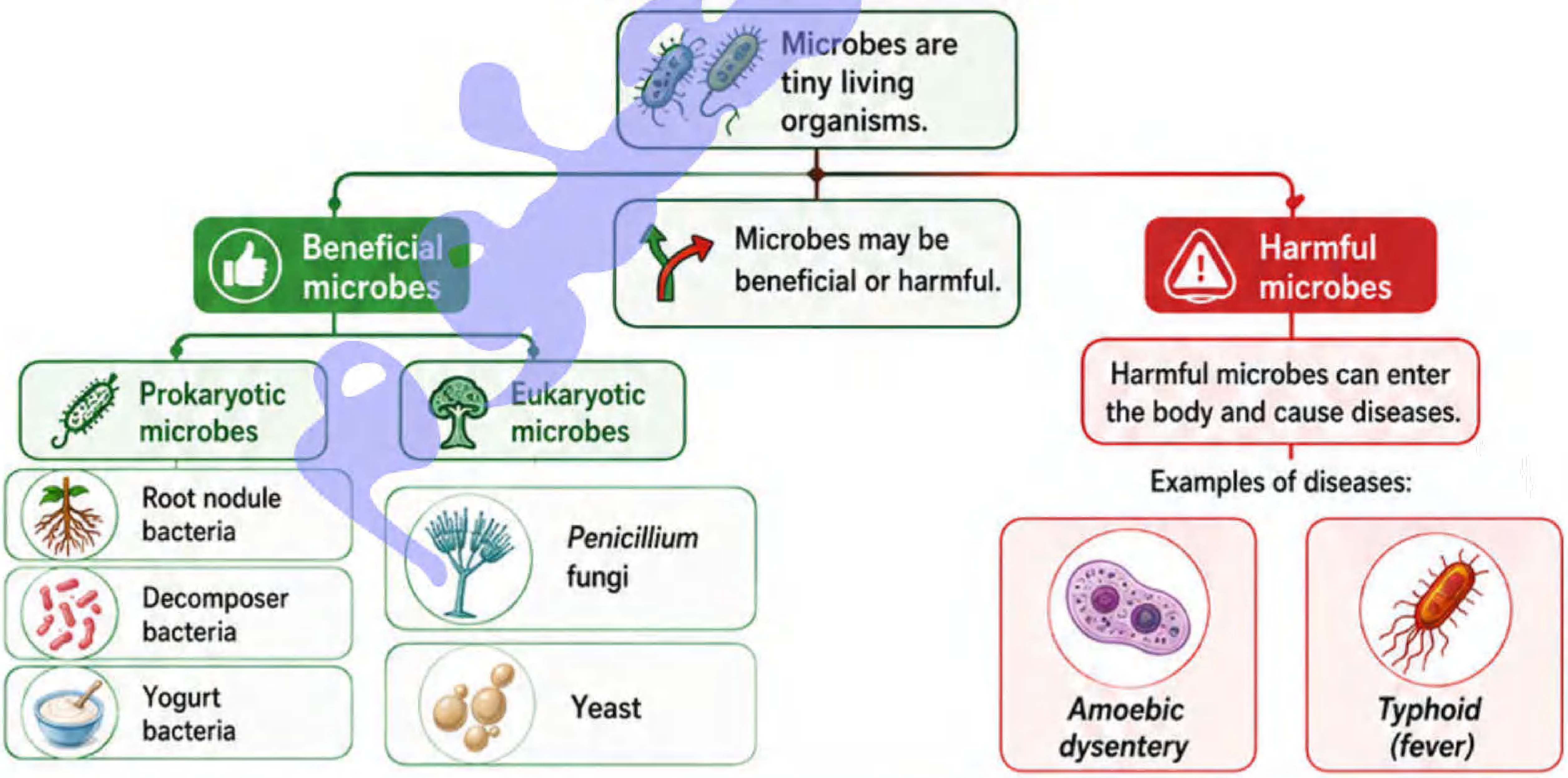


5. Drink at least about three liters of clean water daily.



Healthy habits help keep our bodies strong and prevent many diseases, especially diseases of the digestive system.

Lesson Review Map



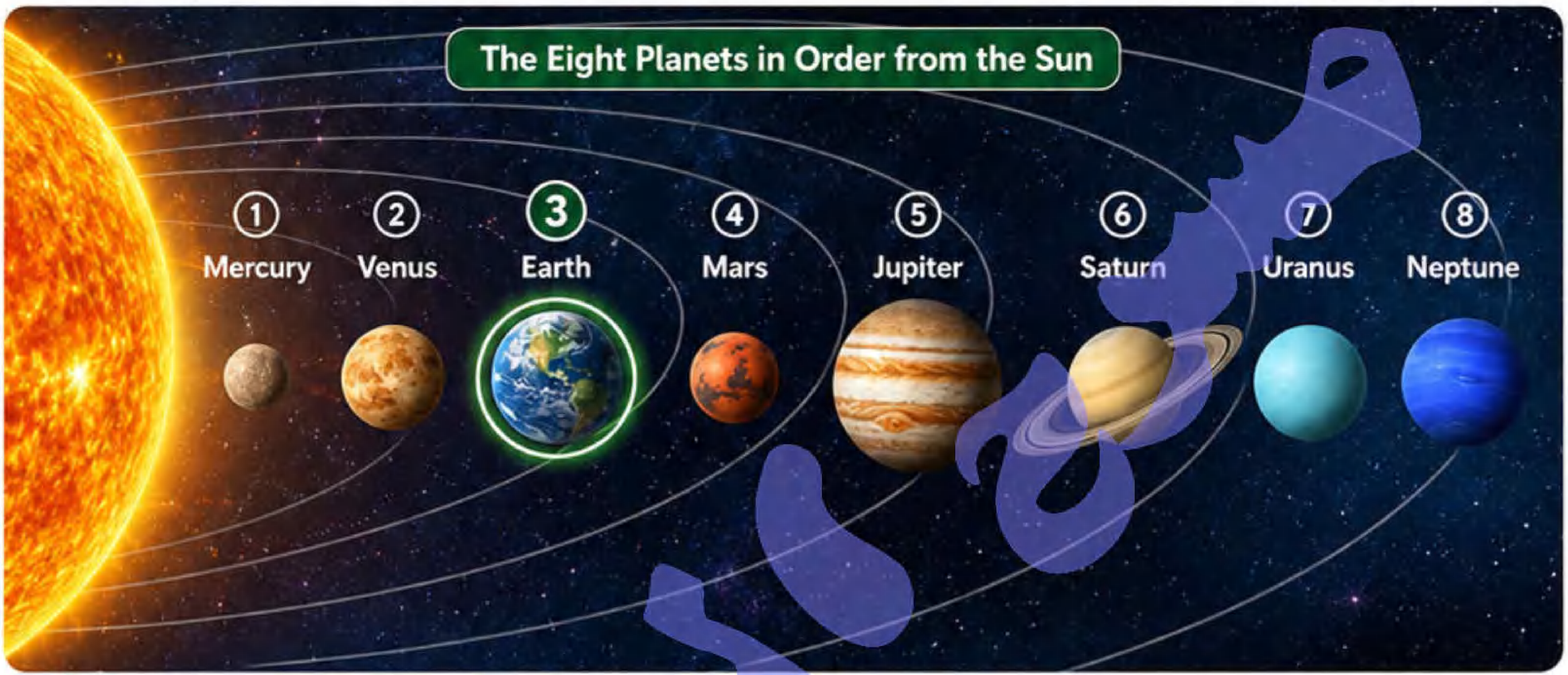
- Microbes are tiny living organisms.
- Microbes may be beneficial or harmful.
  - Beneficial microbes
    - Prokaryotic microbes
      - Root nodule bacteria
      - Decomposer bacteria
      - Yogurt bacteria
    - Eukaryotic microbes
      - *Penicillium* fungi
      - Yeast
  - Harmful microbes
    - Harmful microbes can enter the body and cause diseases.
    - Examples of diseases:
      - *Amoebic dysentery*
      - *Typhoid (fever)*

KEY IDEA: Understanding microbes and following healthy habits help us benefit from useful microbes and avoid harmful ones.

Earth and the Solar System

Our planet and its place in the solar system

The solar system consists of the Sun and all the objects that revolve around it. Among these objects, **the eight planets** are the largest and most important.



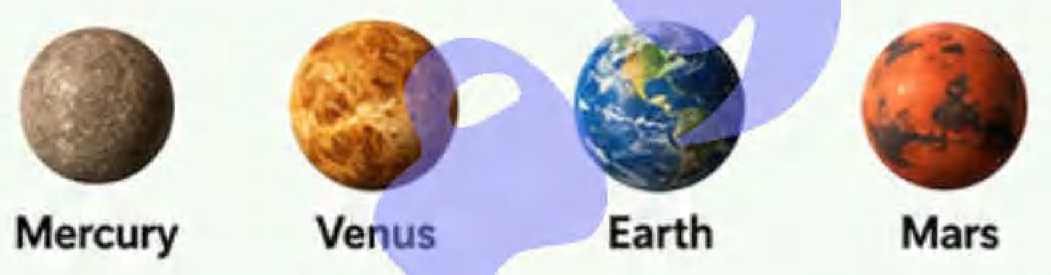
The Eight Planets in Order from the Sun

① Mercury
② Venus
③ Earth
④ Mars
⑤ Jupiter
⑥ Saturn
⑦ Uranus
⑧ Neptune

Two Main Planet Groups

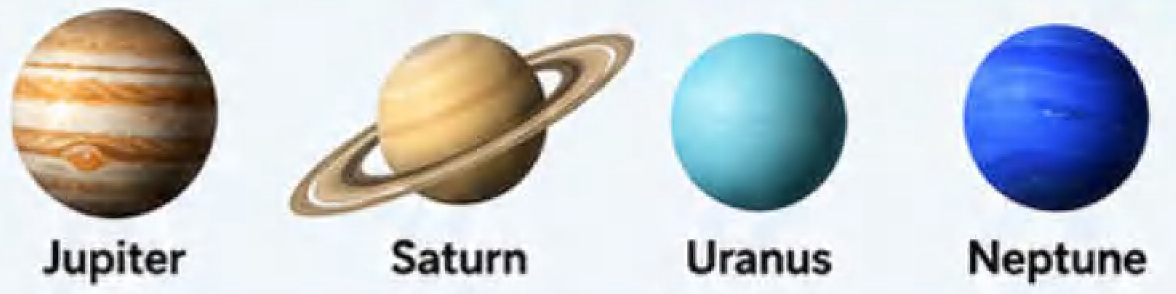
Inner Rocky Planets

These planets are small, made of rock and metal, and have solid surfaces.


Mercury
Venus
Earth
Mars

Outer Gaseous Planets

These planets are very large and made mostly of gases such as hydrogen and helium.


Jupiter
Saturn
Uranus
Neptune

Why Earth is Special

Earth is one of the inner rocky planets. It is the only known planet that has liquid water and life. In this lesson series, we will explore **Earth's motions** and the important **effects** they cause.

KEY IDEA

Earth is part of the solar system. It orbits the Sun along with the seven other planets.

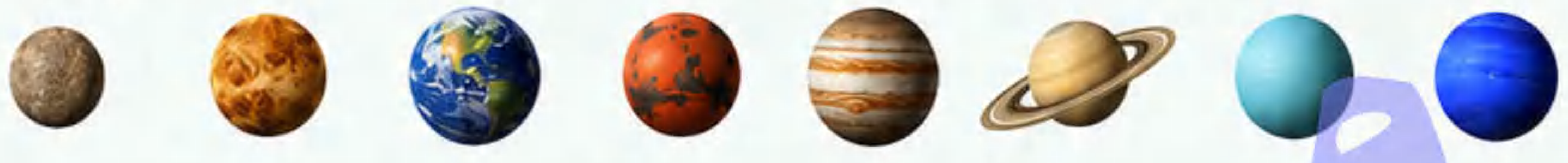
Planet Groups in the Solar System

Comparing the planets by position, composition, and size

The eight planets are arranged in order of their distance from the Sun.

From closest to farthest:

① Mercury → ② Venus → ③ Earth → ④ Mars → ⑤ Jupiter → ⑥ Saturn → ⑦ Uranus → ⑧ Neptune



Two Main Planet Groups

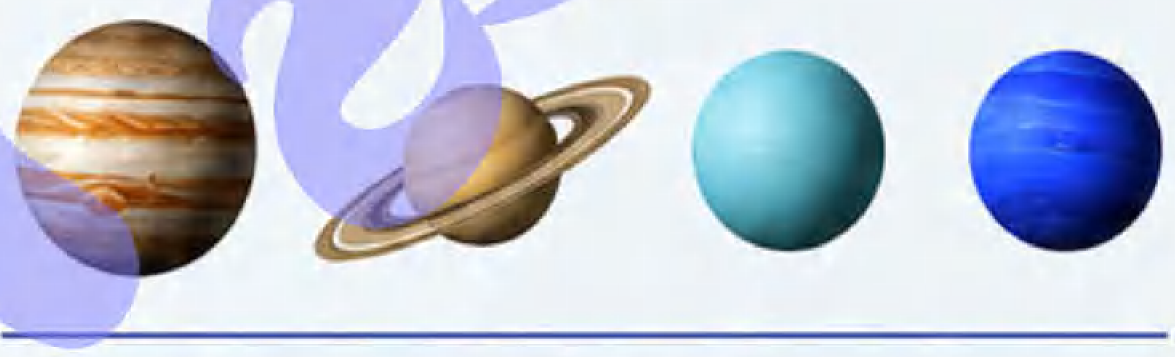
Inner Rocky Planets

Mercury, Venus, Earth, and Mars

These planets are smaller, denser, and have solid surfaces made mainly of **rock** and **metal**.

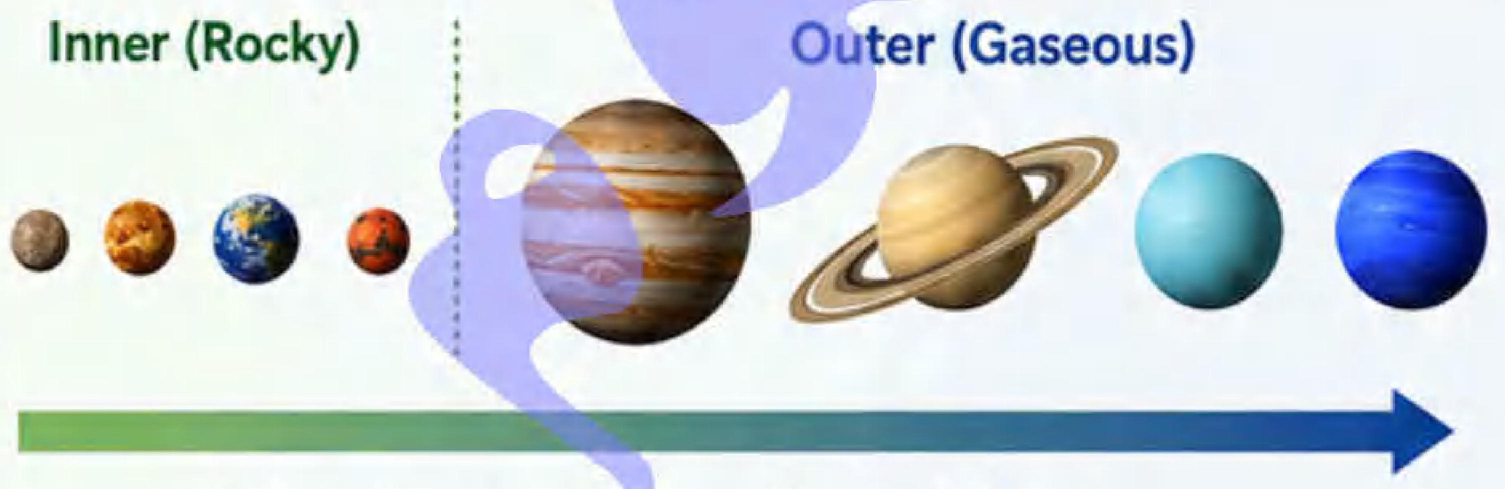
Outer Gaseous Planets

Jupiter, Saturn, Uranus, and Neptune



These planets are much larger and are made mostly of **gases** such as **hydrogen** and **helium**.

Size Comparison



Outer planets are generally much **larger** than inner rocky planets.

Distance from the Sun

The planets are arranged by their distance from the Sun.

Mercury is the closest planet to the Sun.

Neptune is the farthest planet from the Sun.

KEY IDEA

The planets in our solar system differ in **composition**, **size**, and **distance** from the Sun, which places them into two main groups: **inner rocky planets** and **outer gaseous planets**.

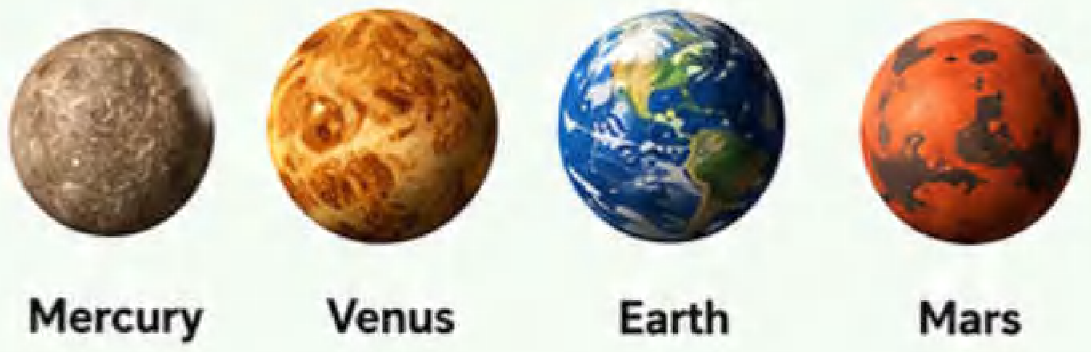
Rocky Planets vs Gaseous Planets

How the two planet groups differ

The planets of our solar system can be classified into two main groups based on their size, composition, and nature: **rocky planets** and **gaseous planets**.

Rocky Planets

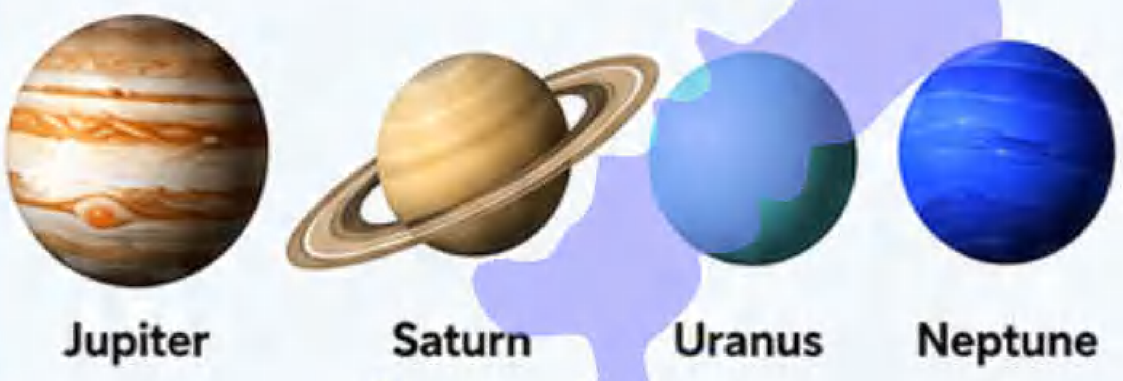
These planets are relatively small, solid, dense, and made of rock and metal.



They have solid surfaces, higher densities, and usually fewer moons.

Gaseous Planets

These planets are very large and are composed mainly of gases such as hydrogen and helium.



They have thick atmospheres, are less dense overall, and have many moons.

How Rocky Planets and Gaseous Planets Compare

Feature	Rocky Planets	Gaseous Planets
Surface Nature	Solid, hard surface (made of rock and metal)	No solid surface; thick layers of gas and ice
Average Size	Small to medium	Very large
Composition	Rock, metal, and silicate minerals	Mostly hydrogen and helium, with traces of other gases
Position in the Solar System	Inner part, close to the Sun (inside the asteroid belt)	Outer part, far from the Sun (beyond the asteroid belt)

Quick Facts

- Jupiter is the nearest gaseous planet to the Sun.
- Neptune is the farthest planet from the Sun.
- The rocky planets are the inner planets.

Why It Matters

Knowing the type of a planet helps scientists predict its size, surface conditions, and the possibility of supporting life.

Think & Apply

If a newly discovered planet is very large and made mostly of hydrogen and helium, which group will it likely belong to? Why?

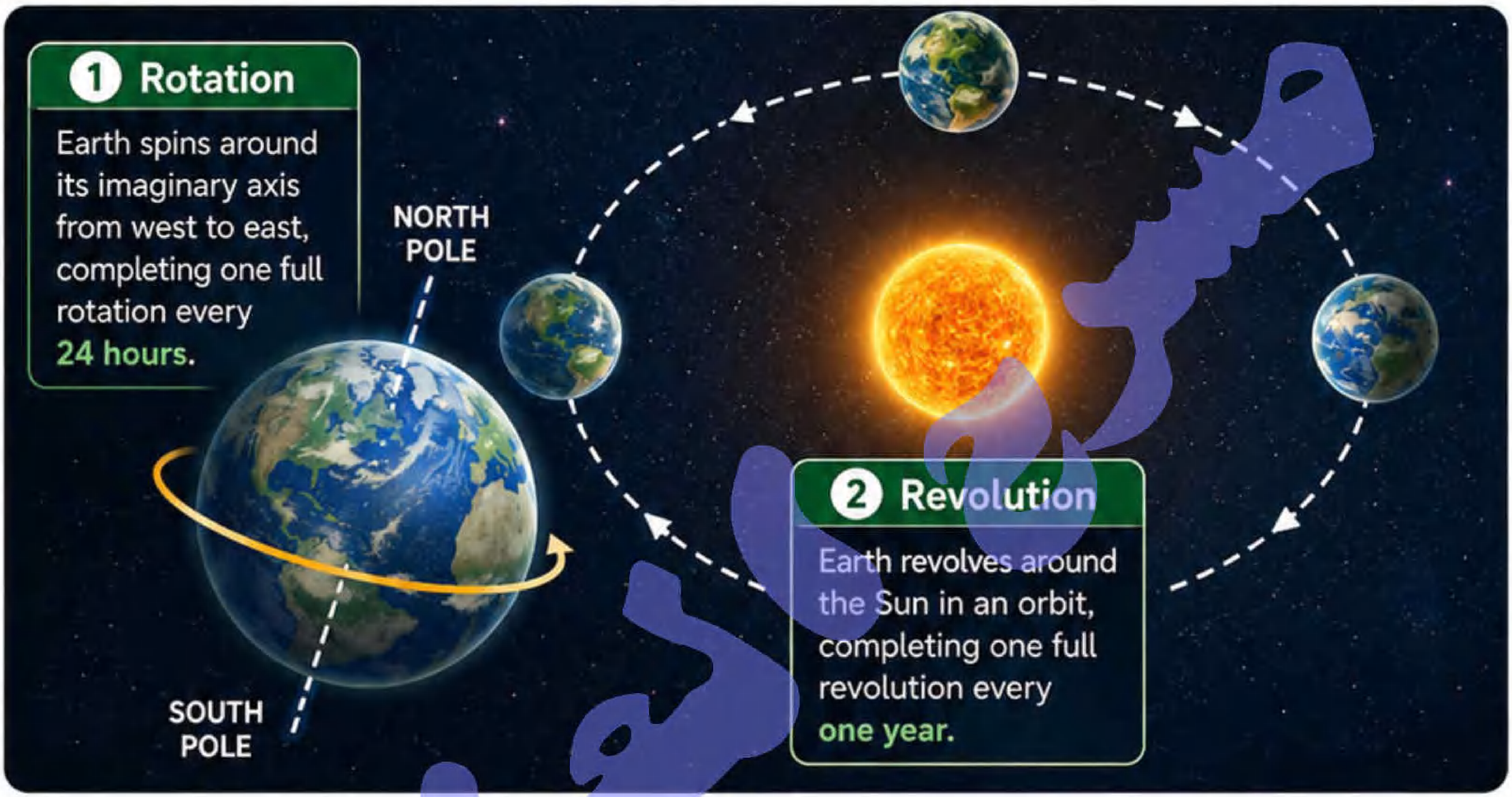
KEY IDEA

The solar system has two main types of planets: rocky planets, which are small and solid, and gaseous planets, which are very large and gas-rich. Their differences are linked to their composition and distance from the Sun.

Earth's Two Motions

Rotation and revolution

Earth has two basic motions. It spins on its axis and revolves around the Sun. These motions shape our days, our seasons, and how we experience our world.



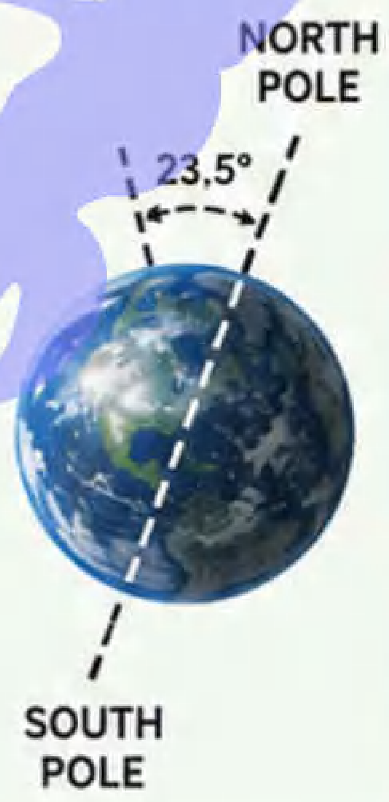
① Rotation

Earth spins around its imaginary axis from west to east, completing one full rotation every **24 hours.**

② Revolution

Earth revolves around the Sun in an orbit, completing one full revolution every **one year.**

Earth's Axis



Earth's axis is an imaginary line that passes through the North Pole and South Pole.

Earth is tilted on this axis by about **23.5°**.

Why These Motions Matter

- They cause day and night.
- They cause the apparent motion of the Sun.
- They cause the seasons.

KEY IDEA

Rotation: Earth spins on its axis from west to east once every 24 hours.

Revolution: Earth moves around the Sun in an orbit once every year.

Earth's Rotation and Its Results

Day and night and the apparent daily motion of the Sun

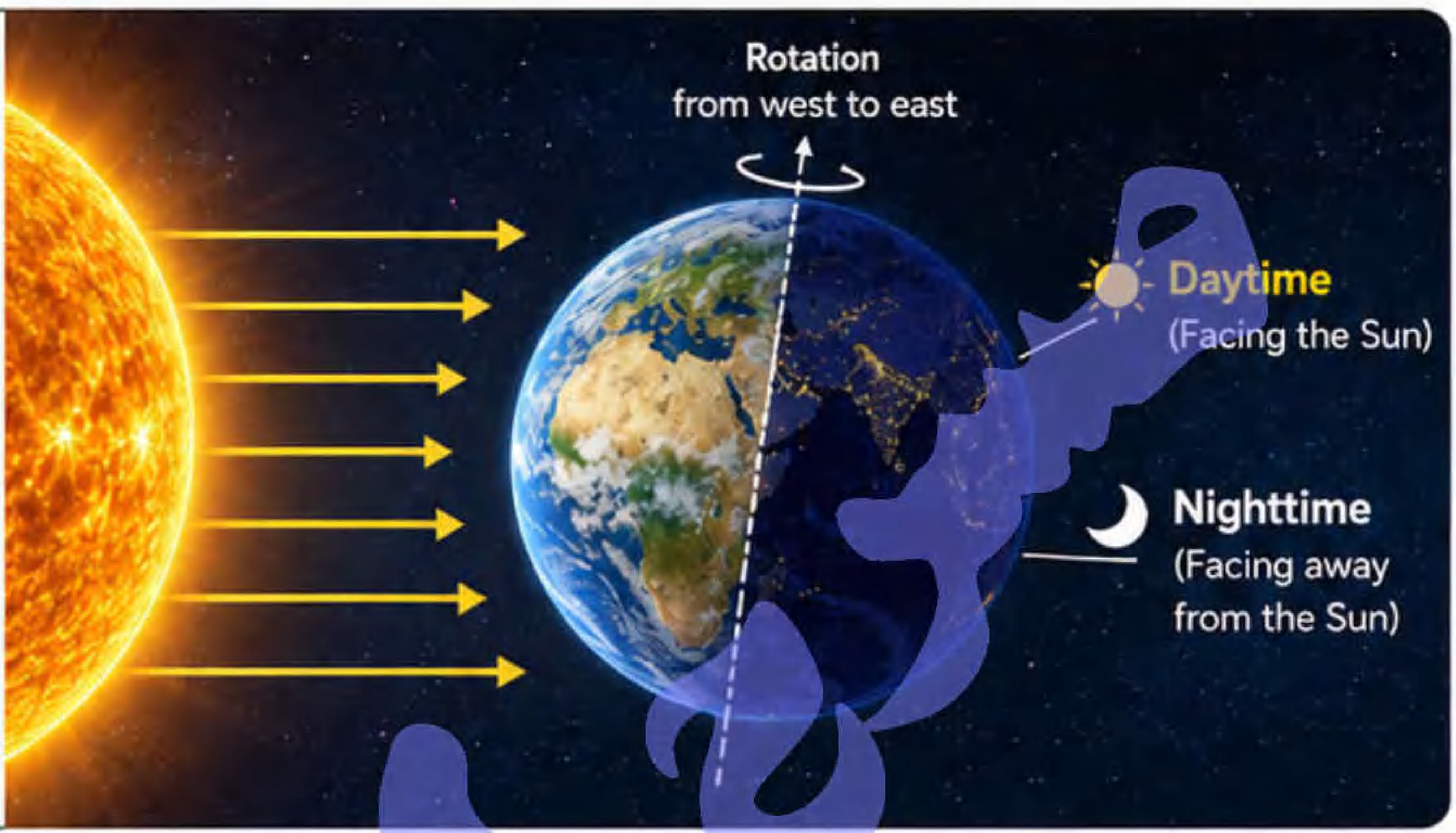
Earth's rotation is the motion of Earth around its axis **from west to east** once every 24 hours.

Result 1: Day and Night

As Earth rotates, each place on Earth alternates between **facing the Sun** and **facing away** from it.

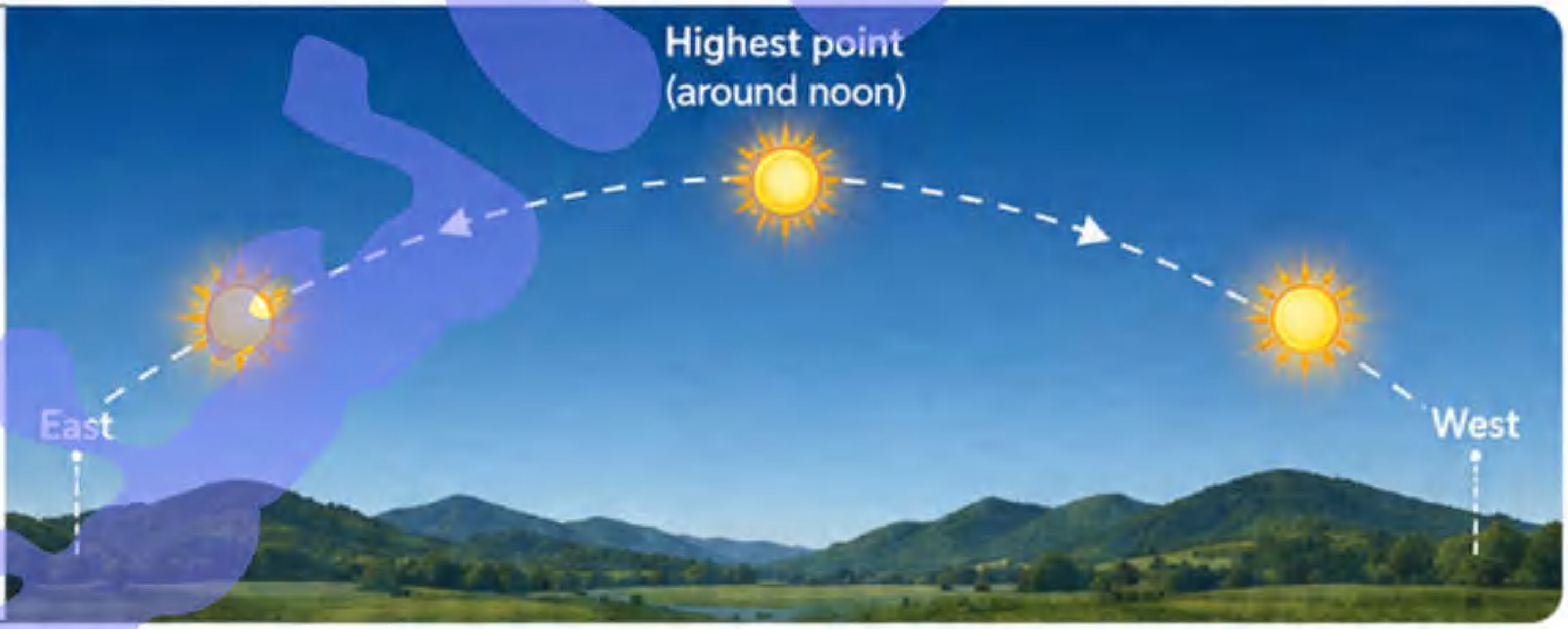
● **Daytime** (Facing the Sun)

☾ **Nighttime** (Facing away from the Sun)


Rotation
from west to east
Daytime
(Facing the Sun)
Nighttime
(Facing away
from the Sun)

Result 2: Apparent Daily Motion of the Sun

Because Earth rotates from west to east, the Sun appears to move across the sky from **east to west**.


Highest point
(around noon)
East
West

The Sun's Daily Path (Apparent Motion)

Sunrise in the East

The Sun appears in the east in the morning.

→

Noon

The Sun reaches its highest point.

→

Sunset in the West

The Sun appears to set in the west in the evening.

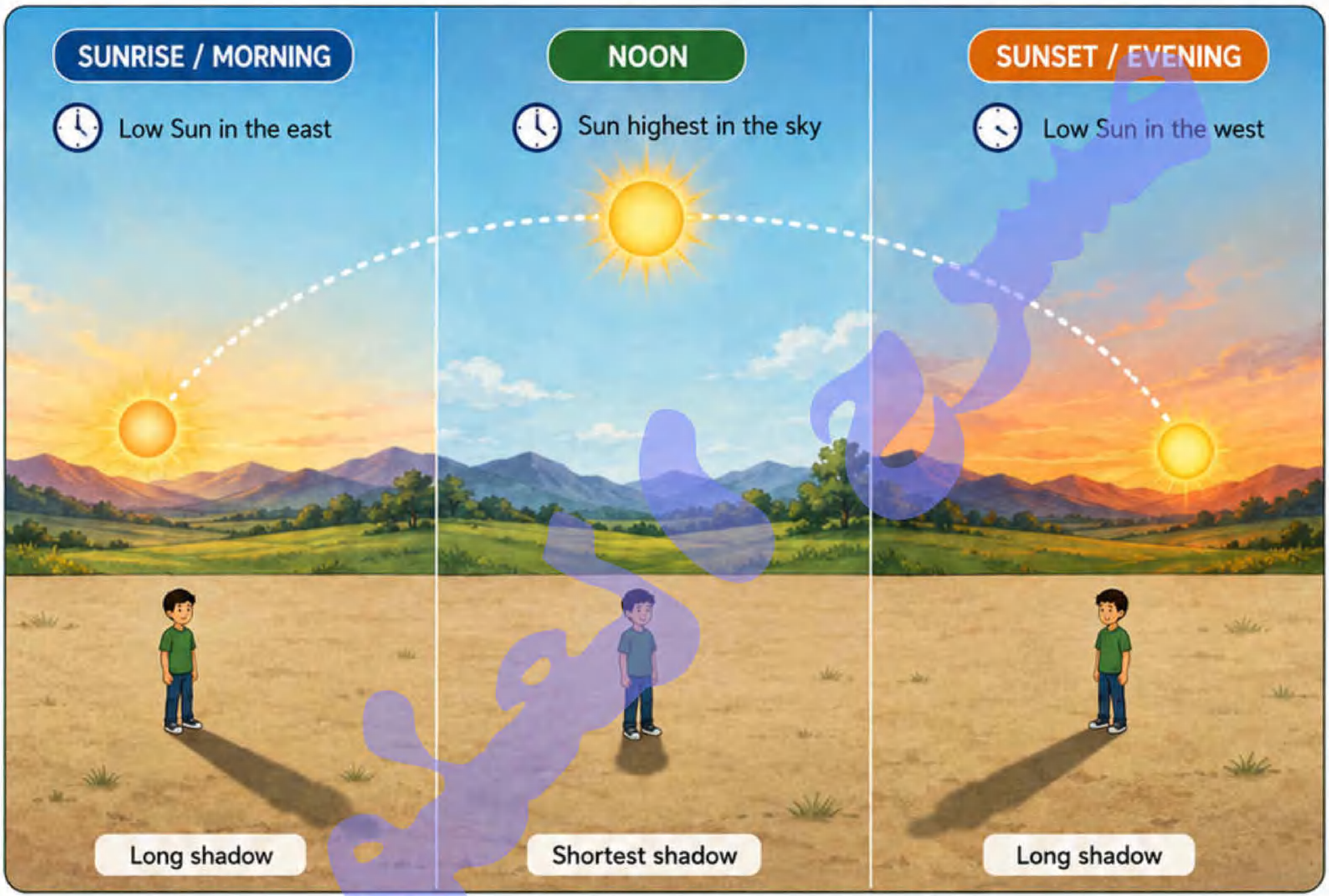
The Sun's apparent movement across the sky is not real motion.
It is an **apparent motion** caused by **Earth's rotation** from **west to east**.

KEY IDEA Earth rotates from west to east once every 24 hours, causing day and night and the Sun's apparent daily motion.

The Sun in the Sky and Shadow Length

How the apparent altitude of the Sun changes during the day

As Earth turns, the Sun appears to move across the sky. Its **apparent altitude** changes from morning to noon to evening.


SUNRISE / MORNING
Low Sun in the east
Long shadow
NOON
Sun highest in the sky
Shortest shadow
SUNSET / EVENING
Low Sun in the west
Long shadow

Important Relationship

The **higher** the apparent altitude of the Sun, the **shorter** the shadow.

The **lower** the apparent altitude of the Sun, the **longer** the shadow.

Key Note

At noon, the Sun reaches its **highest apparent altitude**, so the shadow length is at its **minimum**.

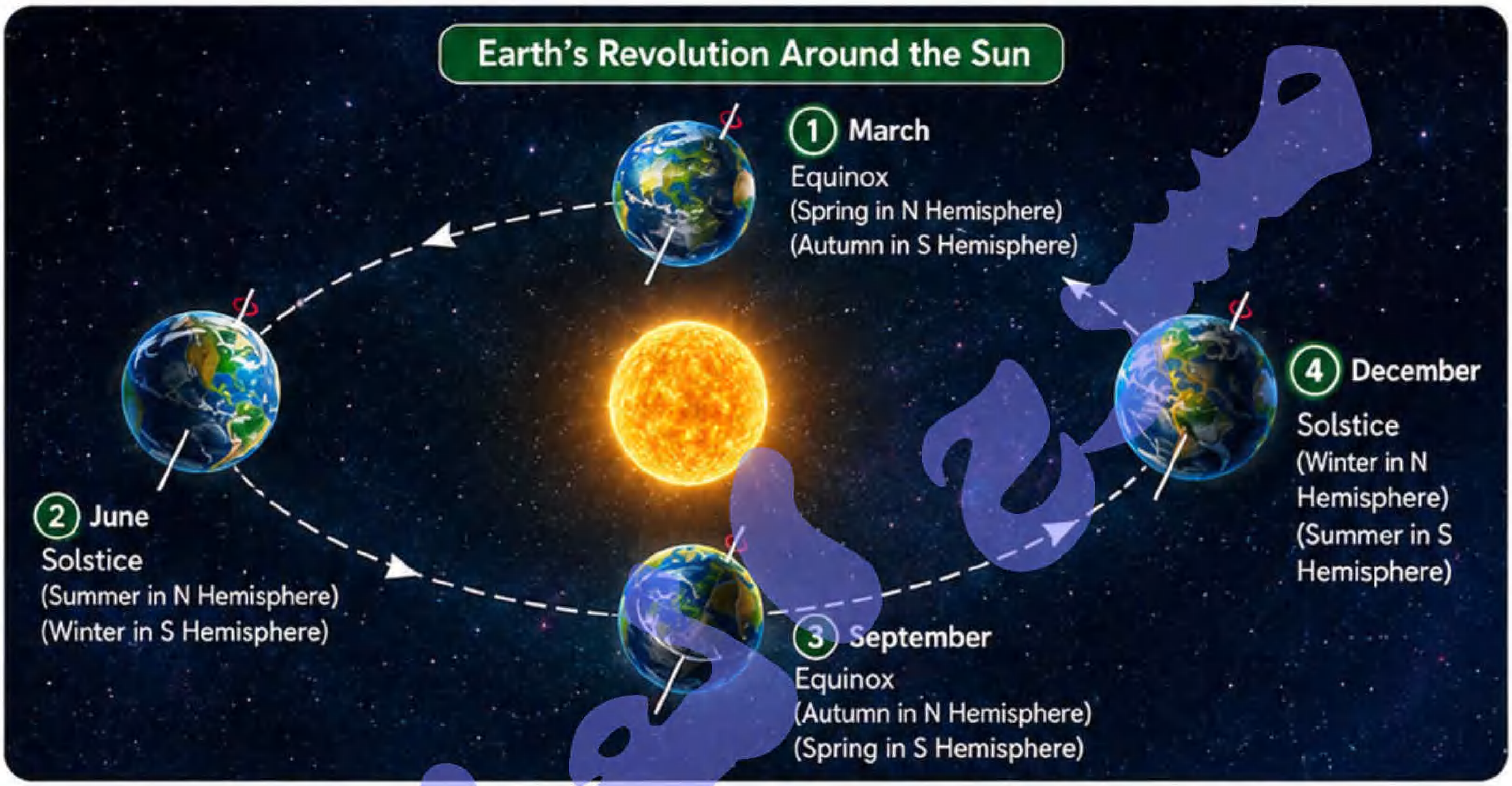
KEY IDEA

The Sun's apparent altitude changes during the day. This change causes the shadow length to change.

Earth's Revolution Around the Sun

A yearly motion that leads to the seasons

Earth **revolves** around the Sun in an orbit. One complete revolution takes about 365¼ days, which we call one **year**.


Earth's Revolution Around the Sun
① March
Equinox
(Spring in N Hemisphere)
(Autumn in S Hemisphere)
② June
Solstice
(Summer in N Hemisphere)
(Winter in S Hemisphere)
③ September
Equinox
(Autumn in N Hemisphere)
(Spring in S Hemisphere)
④ December
Solstice
(Winter in N Hemisphere)
(Summer in S Hemisphere)

What Results from Revolution?

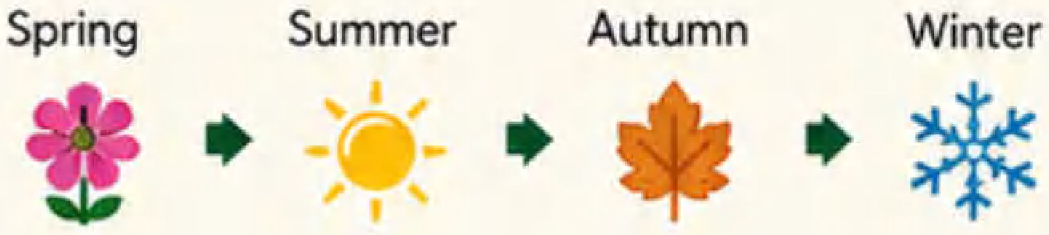
Earth's revolution around the Sun, together with the tilt of its axis, causes the succession of the **four seasons:** spring, summer, autumn, and winter.

Not a Daily Motion

Revolution is not responsible for **day and night**.
Day and night are caused by Earth's **rotation** on its **axis**.

Axis Keeps the Same Tilt

During its revolution, Earth's axis keeps nearly the **same direction** in space. It remains tilted about **23.5°** from the perpendicular to its orbital plane.


Spring
Summer
Autumn
Winter

The seasons follow one another in a **cycle** as Earth continues its **yearly revolution**.

KEY IDEA

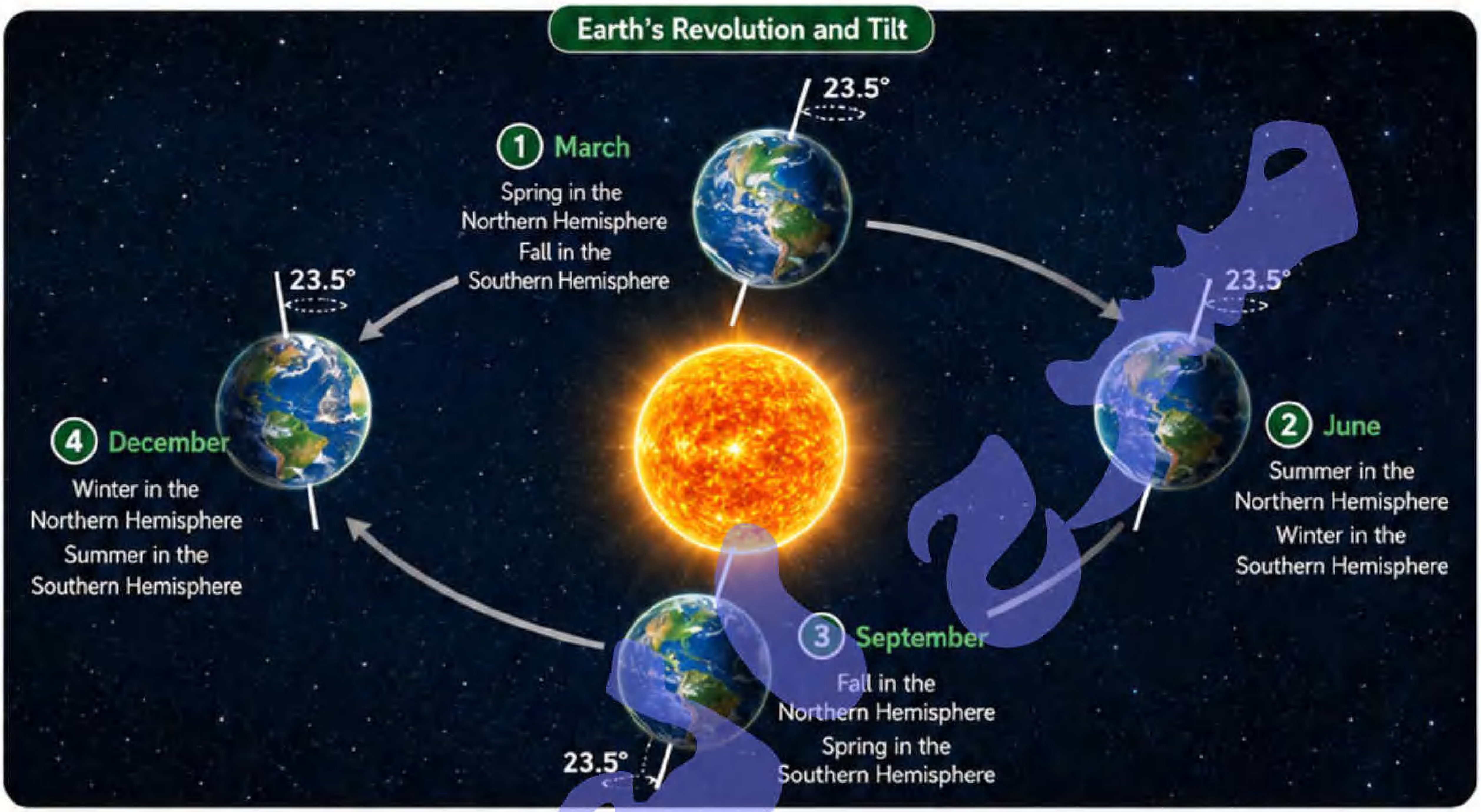
Earth revolves around the Sun once every year.
With its axis tilted in the same direction, this motion causes the succession of the four seasons.

Why Do the Seasons Occur?

Earth's tilted axis and revolution explain seasonal change

The seasons do not occur because Earth is sometimes much nearer to the Sun and sometimes much farther away. Instead, they occur because Earth's **axis is tilted** while **Earth revolves around the Sun**.

Earth's Revolution and Tilt

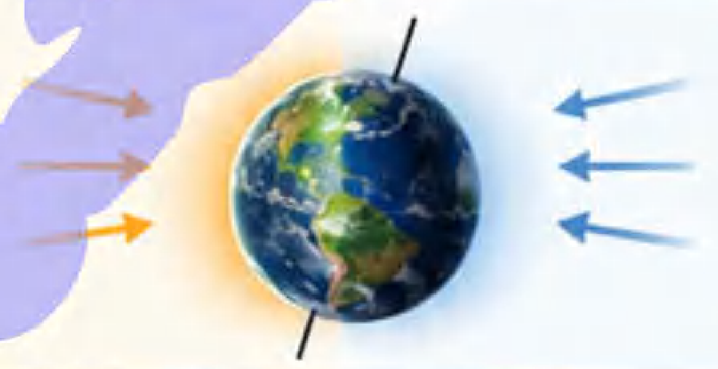


① March
Spring in the Northern Hemisphere
Fall in the Southern Hemisphere

② June
Summer in the Northern Hemisphere
Winter in the Southern Hemisphere

③ September
Fall in the Northern Hemisphere
Spring in the Southern Hemisphere

④ December
Winter in the Northern Hemisphere
Summer in the Southern Hemisphere



Tilted Toward the Sun

That hemisphere receives more direct sunlight.

It has warmer conditions and longer days.

Tilted Away from the Sun

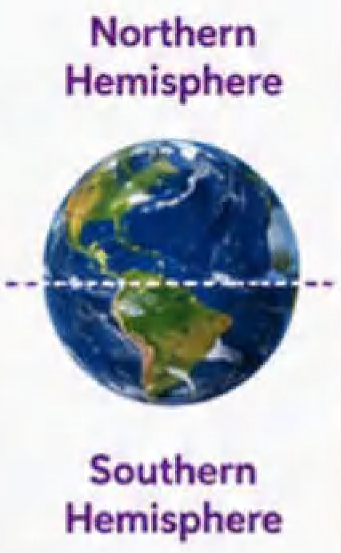
That hemisphere receives less direct sunlight.

It has cooler conditions and shorter days.

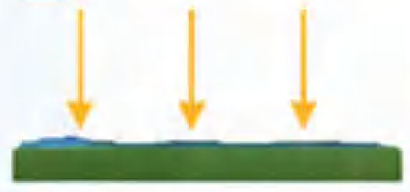
Opposite Seasons

The Northern and Southern Hemispheres experience opposite seasons at the same time of year.

- When the Northern Hemisphere has summer, the Southern Hemisphere has winter.
- When the Northern Hemisphere has winter, the Southern Hemisphere has summer.

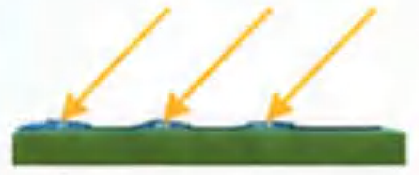


Angle of Sunlight



More Direct Rays

Sunlight hits the surface more perpendicularly, concentrating energy and producing more heating.



Slanted Rays

Sunlight spreads over a larger area, so less energy is received and less heating occurs.

KEY IDEA

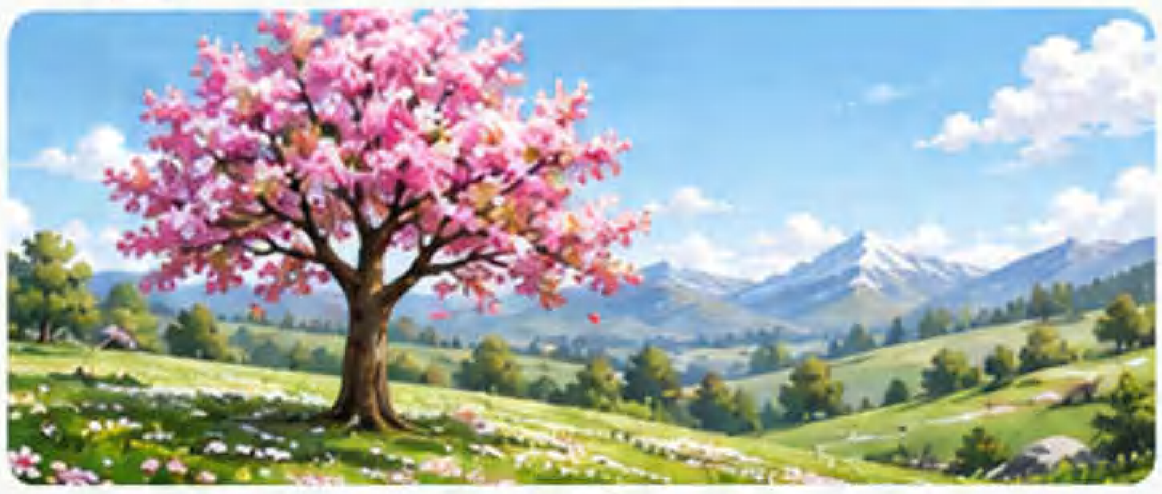
Earth's axis is tilted about 23.5°.
As Earth revolves around the Sun, this tilt causes different amounts of direct sunlight, creating the seasons.

The Four Seasons

Seasonal change in the Northern Hemisphere

SPRING

Starts around March 21

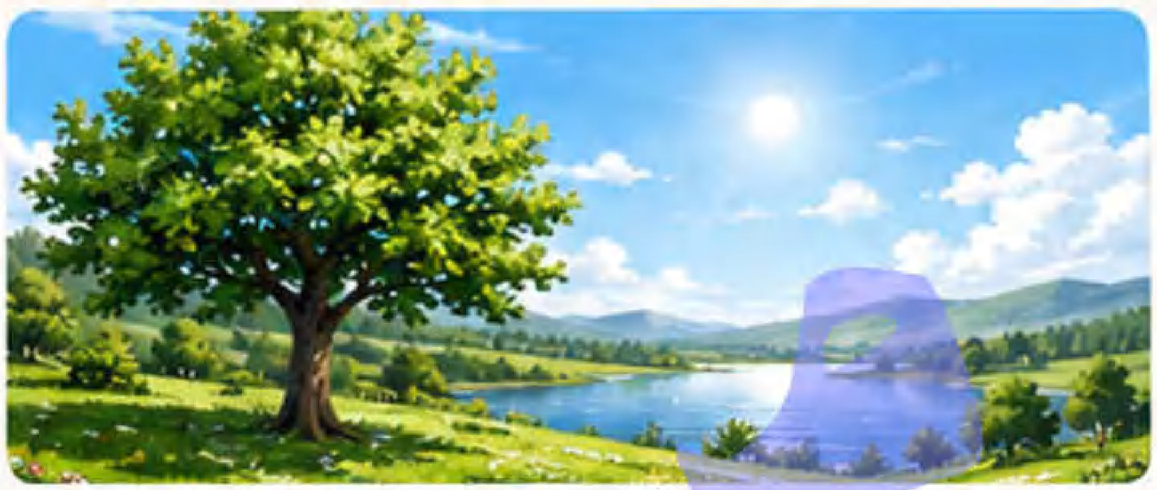


Temperatures become milder. Plants grow new leaves and flowers. Many animals become more active.

Day and night are nearly equal.
Daylight hours and nighttime hours are about the same.

SUMMER

Starts around June 21

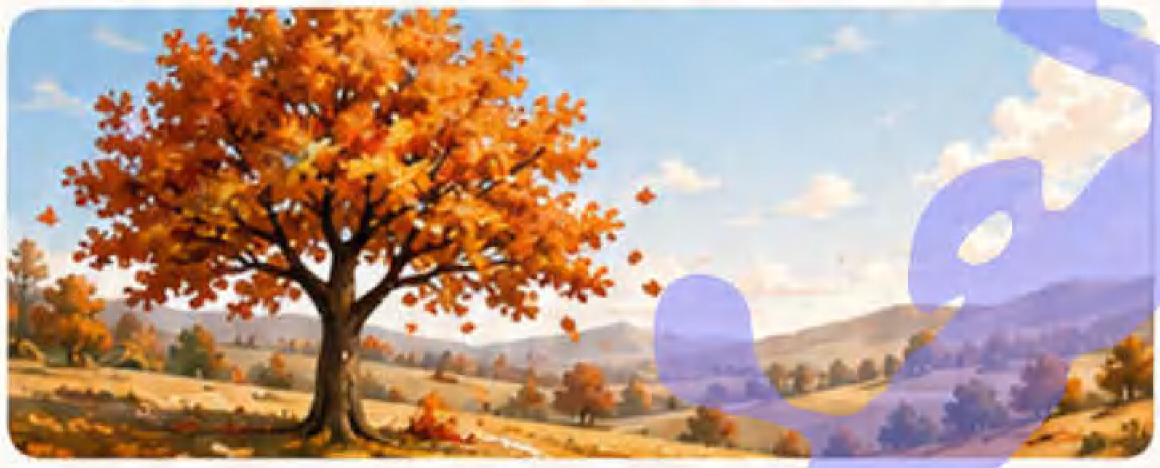


Days are long and warm or hot. Plants are full and green. Many people spend more time outdoors.

Days are longer than nights.
There is more daylight than nighttime.

AUTUMN

Starts around September 23

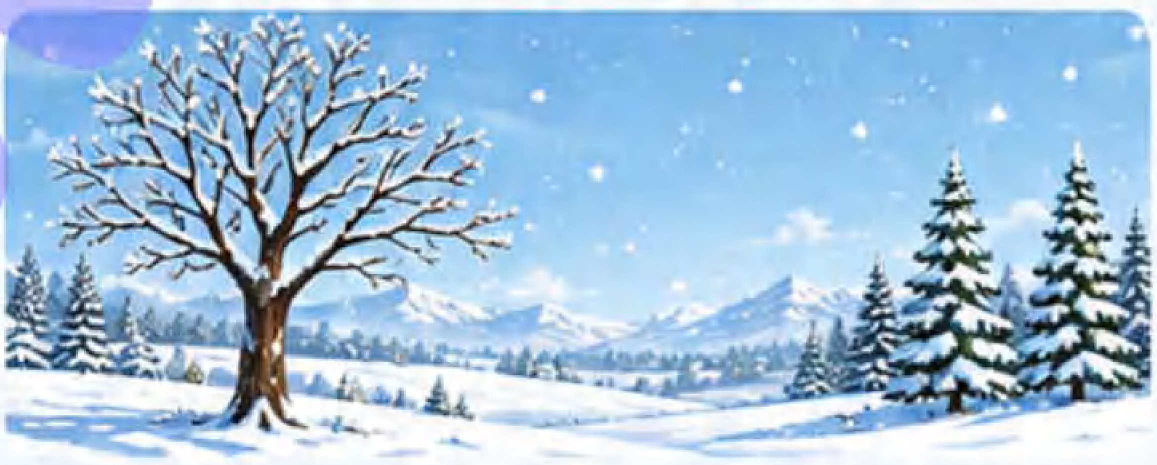


Temperatures become cooler. Leaves change color and fall from trees. Many animals store food for winter.

Day and night are nearly equal.
Daylight hours and nighttime hours are about the same.

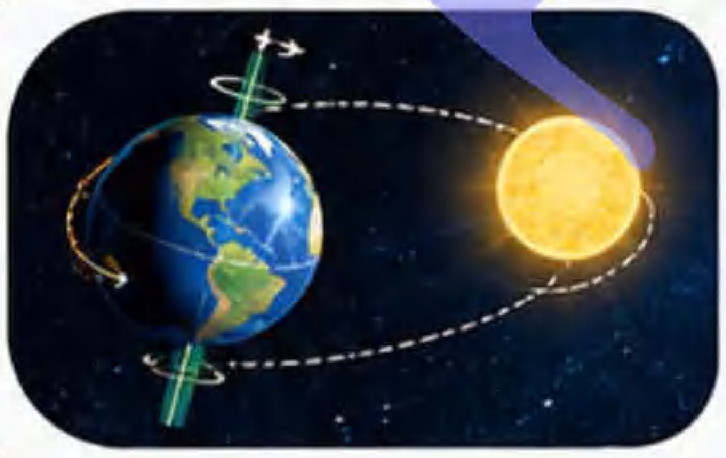
WINTER

Starts around December 21



Days are short and cold. Some trees lose their leaves. Many animals hibernate or stay less active.

Days are shorter than nights.
There is less daylight than nighttime.



Day Length Changes

The number of daylight hours changes from season to season because of two main reasons:

- ✓ Earth's axis is tilted about 23.5°.
- ✓ Earth revolves around the Sun.

As Earth moves, different parts of the Northern Hemisphere receive more or less direct sunlight.

Egypt is in the Northern Hemisphere.

These seasonal patterns are the same ones we observe in our country.

KEY IDEA

The four seasons — spring, summer, autumn, and winter — follow one another in a regular cycle during the year.

Seasonal Changes and Final Review

Weather, daylight, agriculture, and the full lesson map

① Observable Effects of the Seasons

Changes in weather and temperature

Seasons bring hot or cold weather, rainy or dry conditions, and wind changes.

Changes in the length of day and night

Daylight hours are longer in some seasons and shorter in others.

Changes in plant growth and daily life

Plants grow, flower, or rest in different seasons. People's clothes, activities, and work also change.

② Agriculture in Egypt

Some crops grow best in warm seasons, while others grow better in cool seasons. Because of this, farming activities and harvest times change throughout the year to match the seasons.

③ Summer vs. Winter

SUMMER		WINTER
Higher temperature	VS.	Lower temperature
Longer daylight		Shorter daylight

④ Lesson Review Map

The Solar System

Earth is one of the planets.

→

Rocky and Gaseous Planets

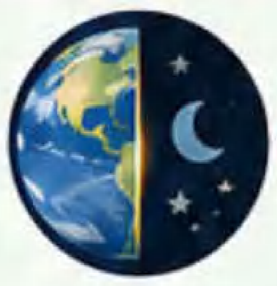
Planets come in two main groups.

→

Earth's Rotation

Earth spins on its axis.

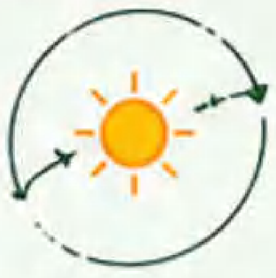
→



Day and Night

Rotation causes day and night.

→



Apparent Motion of the Sun

The Sun seems to move across the sky.

→

Earth's Revolution + Tilted Axis

Earth orbits the Sun, and its axis is tilted.

→

Four Seasons

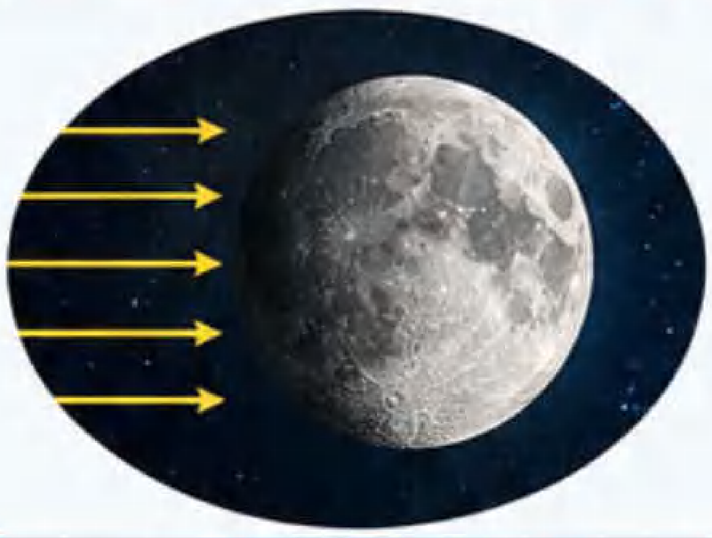
These cause the four seasons.

KEY IDEA

Earth is part of the solar system. Its two main motions—**rotation** and **revolution with a tilted axis**—cause day and night, the apparent motion of the Sun, and the four seasons.

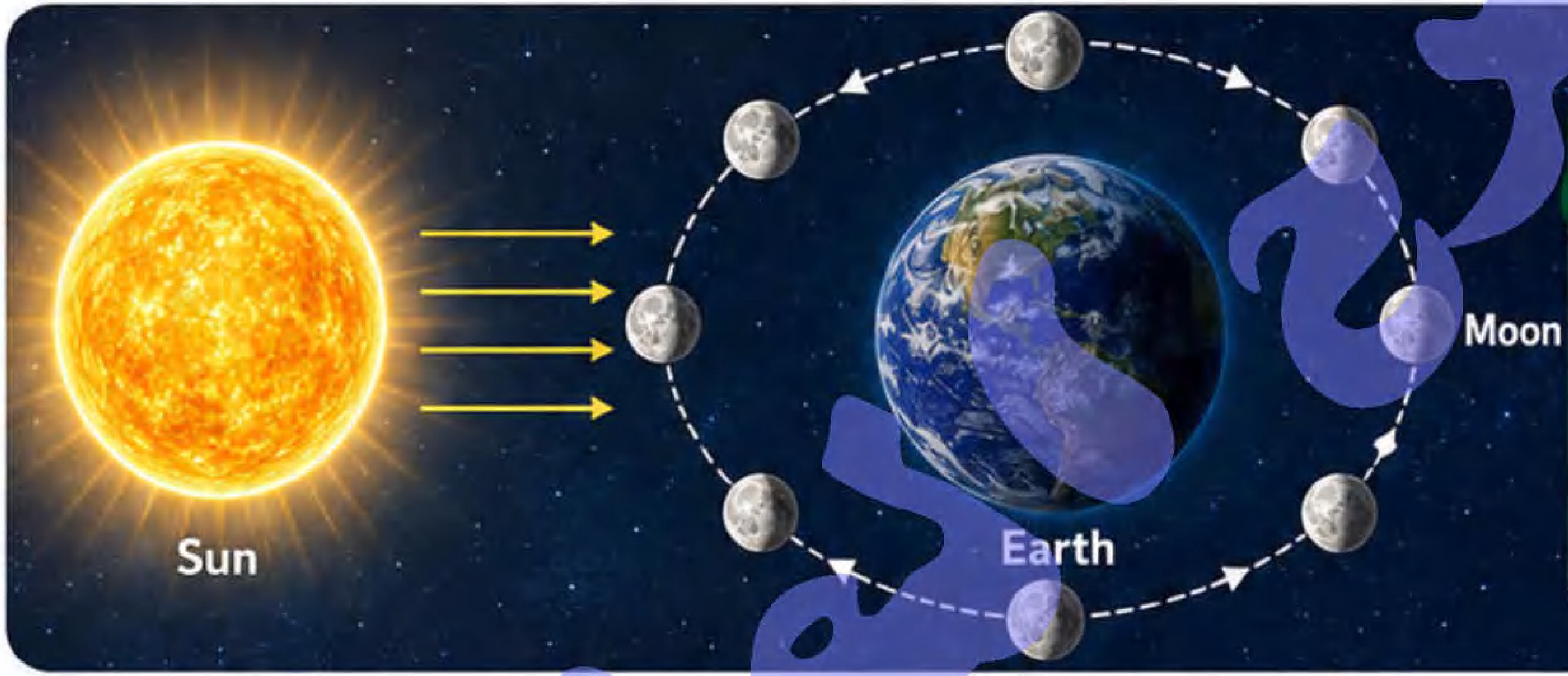
The Moon, Its Phases, and Lunar Eclipse

Why the Moon changes shape and how a lunar eclipse happens



The Moon does not produce its own light.

The Sun shines on the Moon. The Moon's surface reflects that light. We see the part of the Moon that is lit by the Sun.

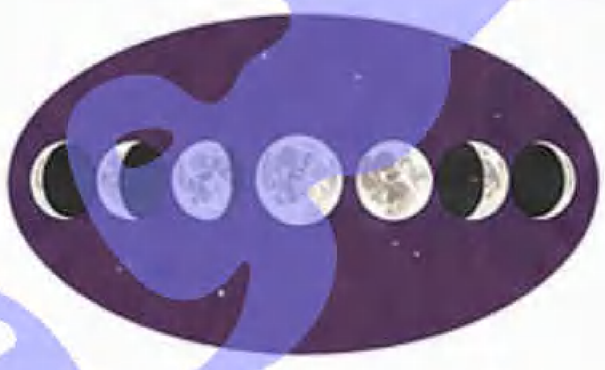


As the Moon orbits Earth, the changing relative positions of the Sun, Earth, and Moon produce the Moon's phases.

Main Ideas in This Lesson

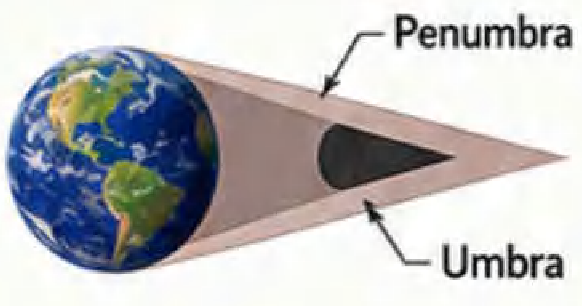
1. Moon Phases

The visible illuminated part of the Moon changes during its orbit around Earth.



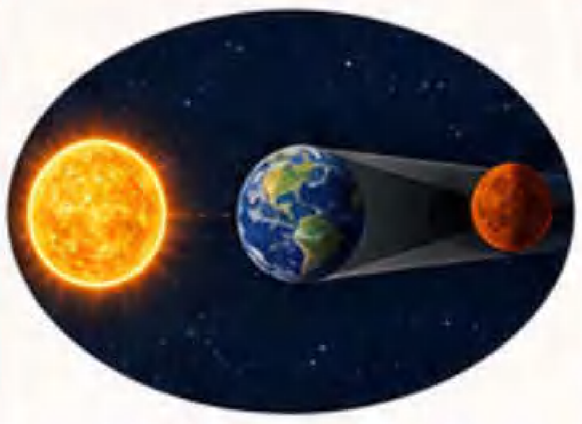
2. Eight Common Phases

New moon, crescent, first quarter, gibbous, full moon, then the phases decrease again.



3. Shadow and Penumbra

When light is blocked, a shadow region (umbra) and a penumbra region can form.



4. Lunar Eclipse

Happens when Earth is between the Sun and the Moon and Earth blocks sunlight from reaching the Moon.

Key Idea

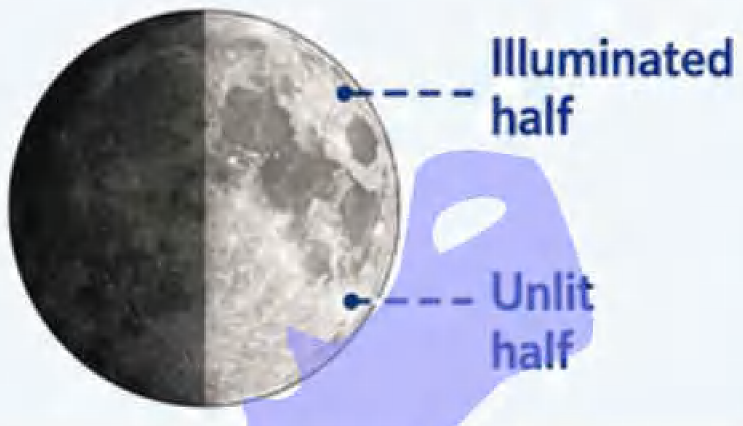
The Moon reflects sunlight. • Its phases depend on its position relative to Earth and the Sun. • A lunar eclipse occurs when Earth blocks sunlight from the Moon.

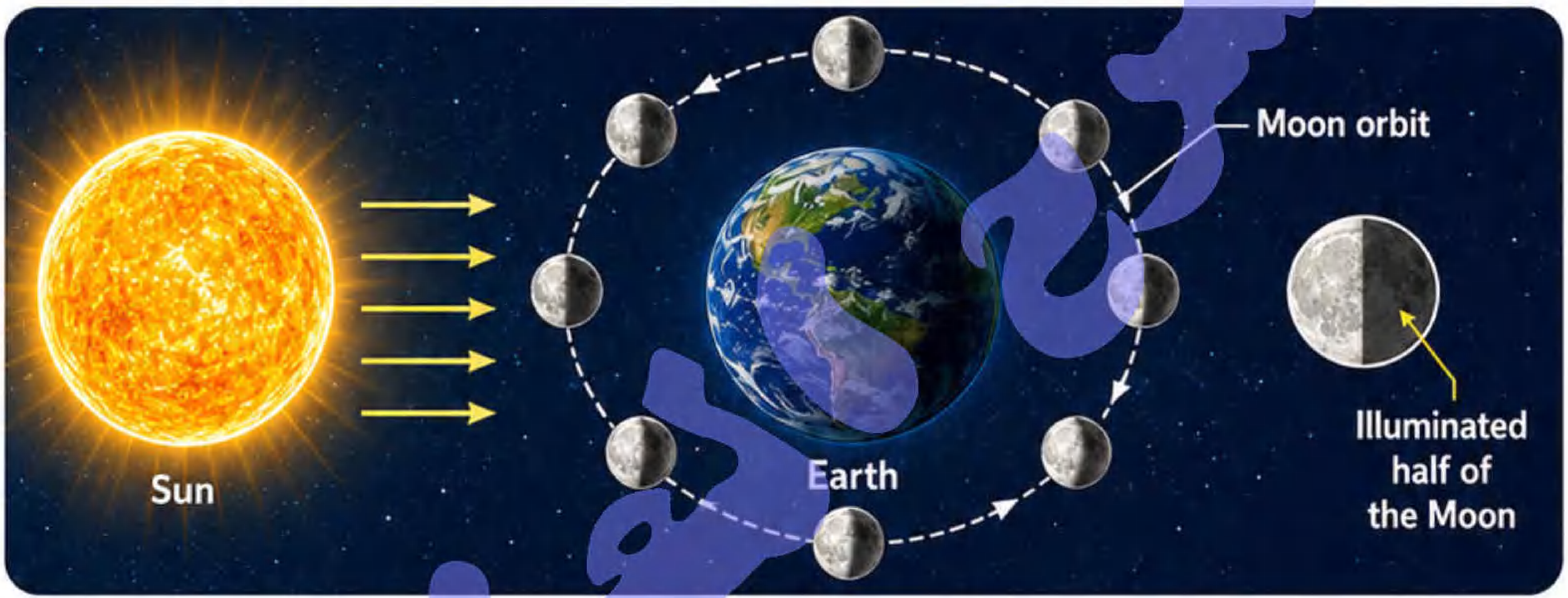
Why the Moon Changes Shape

Moon phases depend on the Moon's position relative to Earth and the Sun

The Moon does not change its real shape.

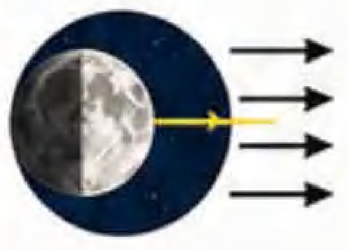
The Sun always lights one half of the Moon. As the Moon orbits Earth, the amount of the lit half that we see from Earth changes.





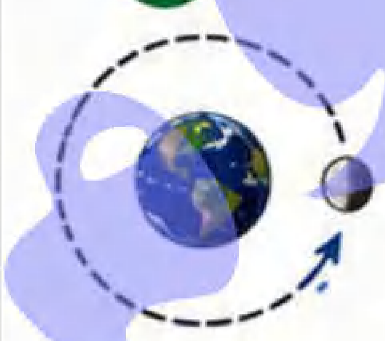
What Causes Moon Phases?

①



The Sun always lights half of the Moon.

②

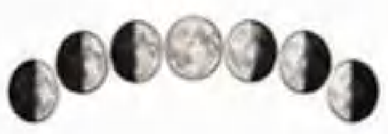


The Moon revolves around Earth.

③

We see different portions of the illuminated half.

④



This changing view produces the Moon's phases.

The Lunar Month

The cycle of Moon phases repeats about once every **lunar month**—about 29.5 days.

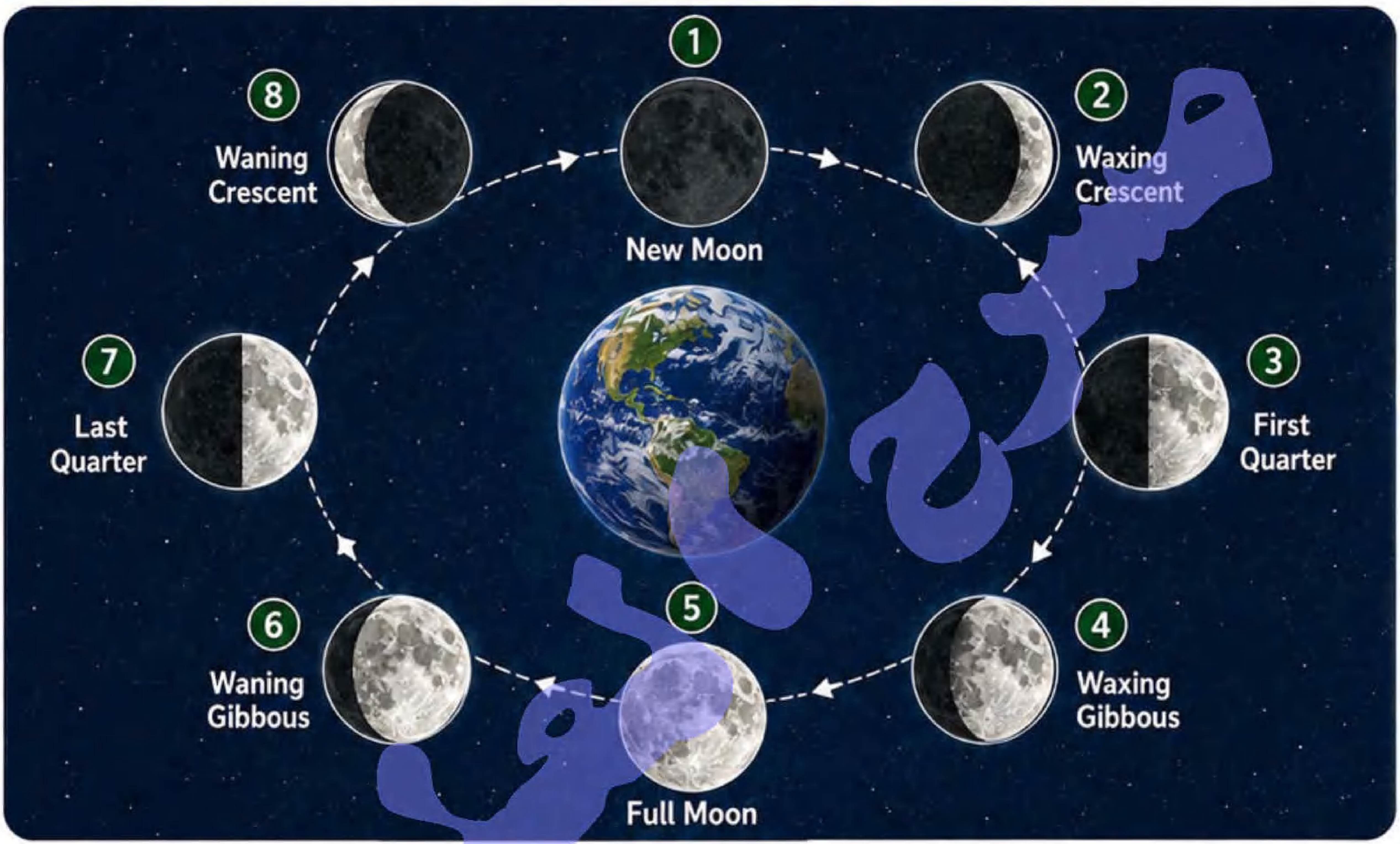
Key Idea

Moon phases are caused by the changing relative positions of the Sun, Earth, and Moon, not because the Moon changes shape.

The Eight Phases of the Moon

The changing appearance of the Moon during its orbit around Earth

The Moon passes through eight common phases in order.
As the Moon orbits Earth, the amount of the sunlit side we see changes.


① New Moon
② Waxing Crescent
③ First Quarter
④ Waxing Gibbous
⑤ Full Moon
⑥ Waning Gibbous
⑦ Last Quarter
⑧ Waning Crescent

Two Main Periods

Waxing
The illuminated part increases each night.

Waning
The illuminated part decreases each night.

Important Notes

Full Moon
Earth is between the Sun and Moon.
No eclipse unless there is perfect alignment.
The full moon appears fully lit.

New Moon
The Moon is between the Sun and Earth.
The side facing Earth is dark, so we cannot see it.

Key Idea

The Moon goes through eight phases in this order:

❶ → ❷ → ❸ → ❹ → ❺ → ❻ → ❼ → ❽

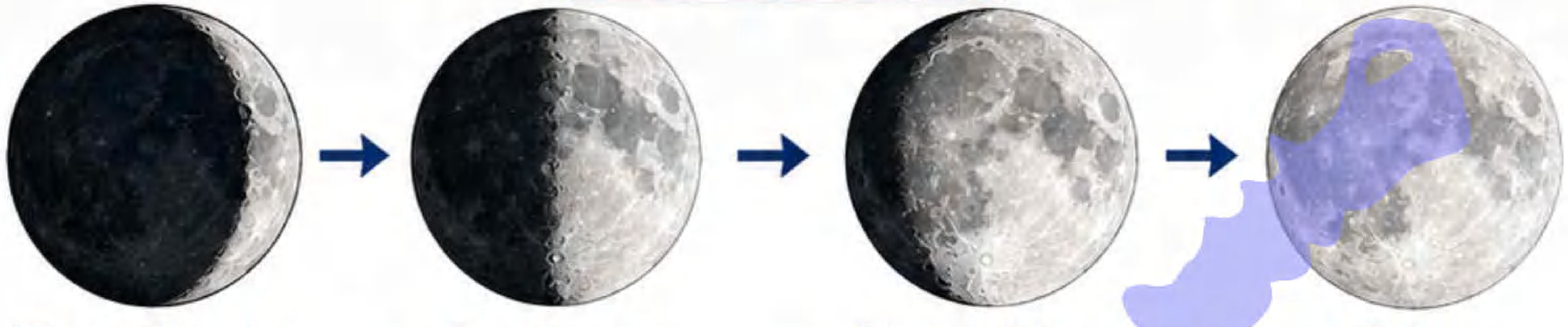
Waxing and Waning Moon

How the illuminated part increases and then decreases

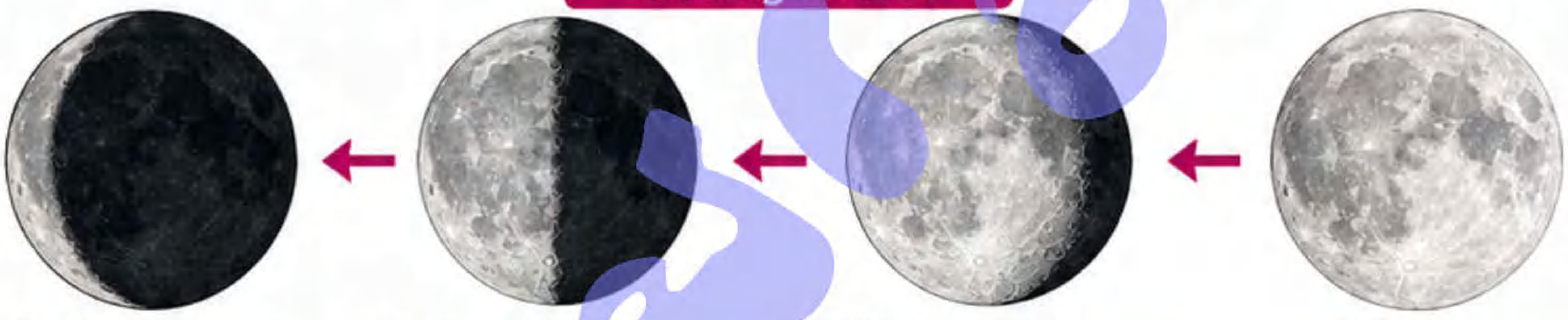
During the first half of the lunar cycle, the visible lit area increases. This is called **waxing**.

During the second half of the lunar cycle, the visible lit area decreases. This is called **waning.**

Waxing Phases


Waxing Crescent → First Quarter → Waxing Gibbous → Full Moon

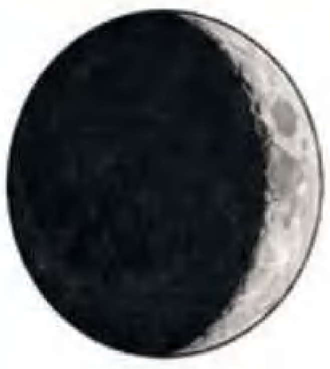
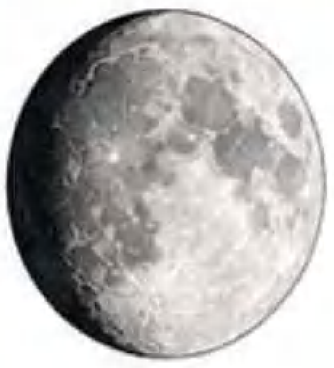
Waning Phases


Waning Crescent ← Last Quarter ← Waning Gibbous ← Full Moon

First Quarter vs Last Quarter

	First Quarter	Last Quarter
◐	Both show half of the Moon illuminated.	Both show half of the Moon illuminated.
↗	First Quarter happens in the **waxing** half of the cycle.	Last Quarter happens in the **waning** half of the cycle.

Crescent vs Gibbous

Crescent	Gibbous
 Less than half illuminated.	 More than half illuminated.

When Does the Full Moon Occur?

The Full Moon occurs in the middle of the lunar month, when the visible face of the Moon appears fully illuminated.

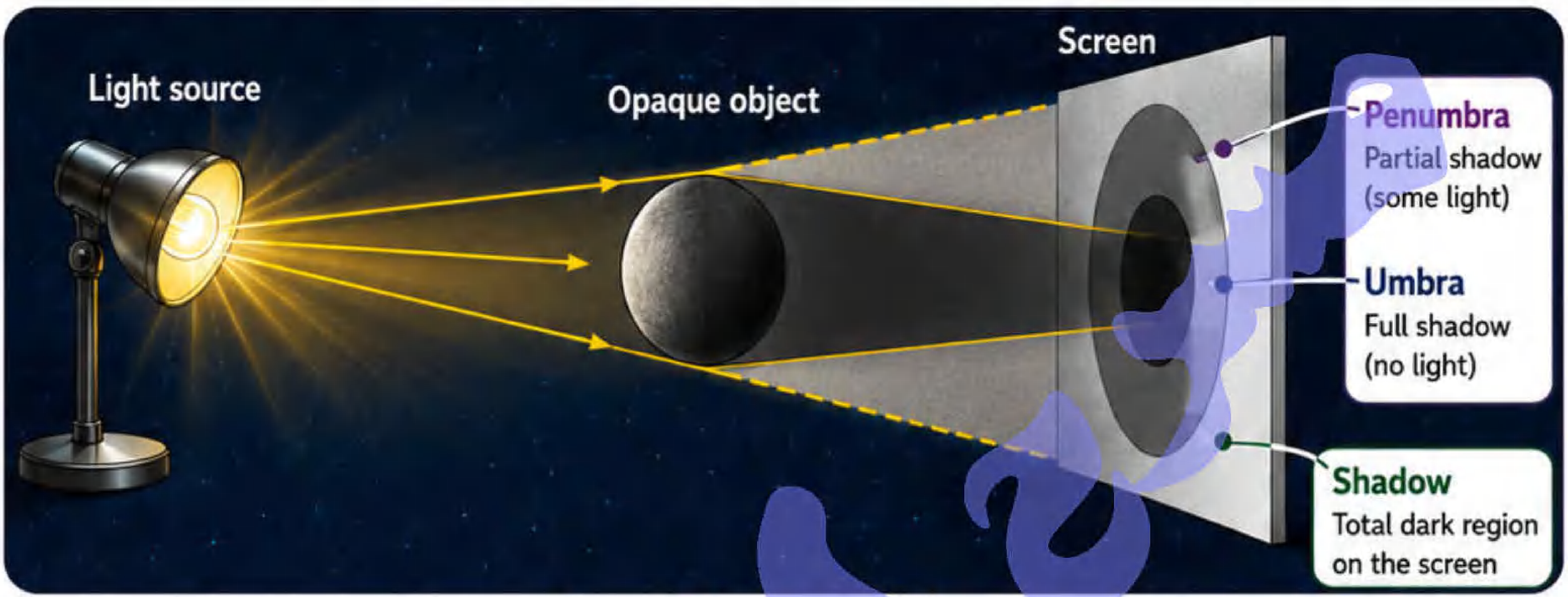
Key Idea

Waxing means the lit part of the Moon increases from New Moon to Full Moon. **Waning** means the lit part decreases from Full Moon back to New Moon.

Light, Shadow, Umbra, and Penumbra

Why fully dark and partially dark regions form when light is blocked

When an opaque object blocks light traveling in straight lines, a dark **shadow** is formed on a surface behind it.



Penumbra
Partial shadow (some light)

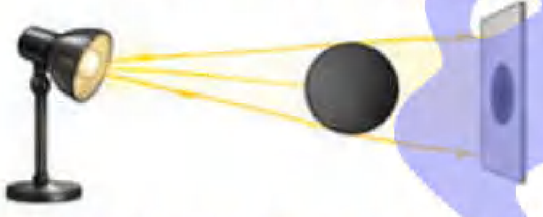
Umbra
Full shadow (no light)

Shadow
Total dark region on the screen

Key Terms

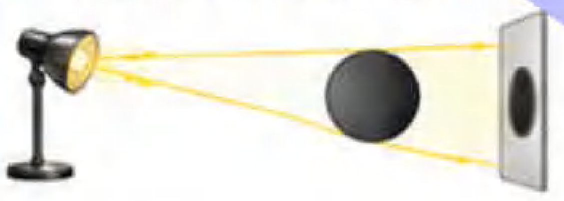
Shadow	Umbra	Penumbra	Opaque object
The dark area on a surface where light is blocked by an opaque object.	The fully dark region where the light source is completely blocked.	The partially dark region where only part of the light source is blocked.	An object that does not let light pass through it.

What Happens if the Light Source Moves?



Move the light source closer to the object.

Smaller shadow

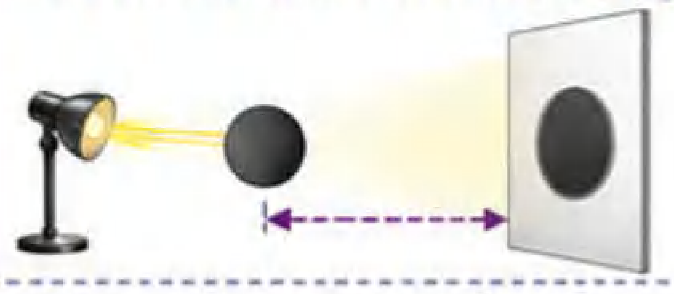


Move the light source farther from the object.

Larger shadow

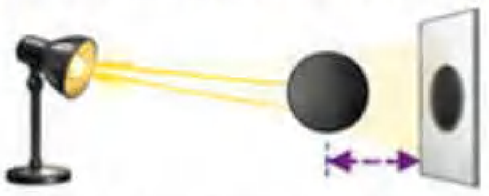
Turning or moving the light changes how much of the object blocks the light, so the shadow size changes.

Does Distance Between Object and Screen Matter?



Move the screen farther away.

Larger shadow



Move the screen closer.

Smaller shadow

The shadow gets larger as the screen is moved farther from the object, and smaller as it is moved closer.

Key Idea

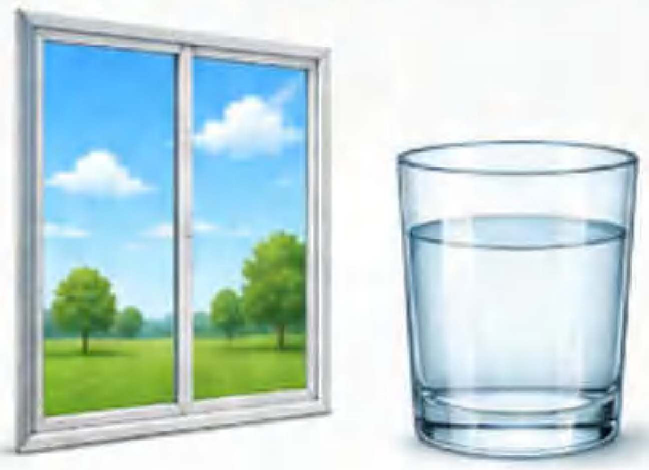
Umbra is the region with no light. • Penumbra is the region with some light. • Shadow size depends on the positions of the light source, object, and screen.

Transparent, Translucent, and Opaque Materials

How different materials interact with light

Materials differ in how much light they allow to pass through.
This affects how clearly we can see objects on the other side and whether shadows form.

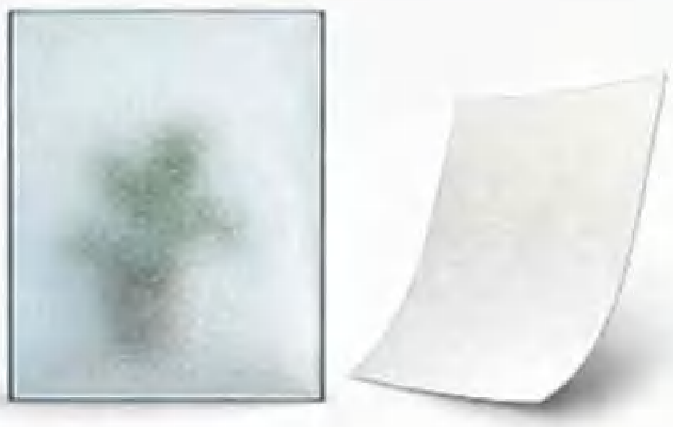
1. Transparent Materials



Allow most light to pass through **clearly.**

✓ **Examples:** clear glass, clean water.

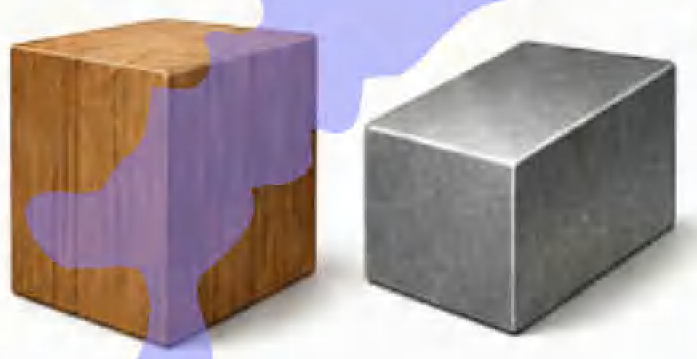
2. Translucent Materials



Allow some light through but **do not give a clear image.**

✓ **Examples:** frosted glass, thin paper.

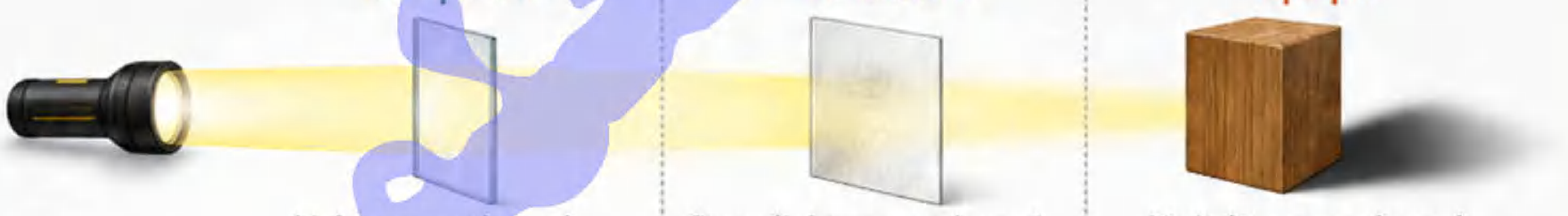
3. Opaque Materials



Do not allow light to pass through.

✓ **Examples:** wood, metal, cardboard.

What Happens When Light Shines Through?



Light passes through **clearly.** You can see the object on the other side.

Some light passes through, but the image is **blurred** and not clear.

No light passes through. A **dark shadow** forms behind the object.

Link to Shadows

- **Opaque** objects block light and form clear shadows.
- **Translucent** materials weaken and blur light, so shadows are faint and unclear.
- **Transparent** materials allow light through, so shadows are very faint or not visible.

Think

Why does a wooden block form a shadow, while clear glass usually does not form the same kind of dark shadow? ?

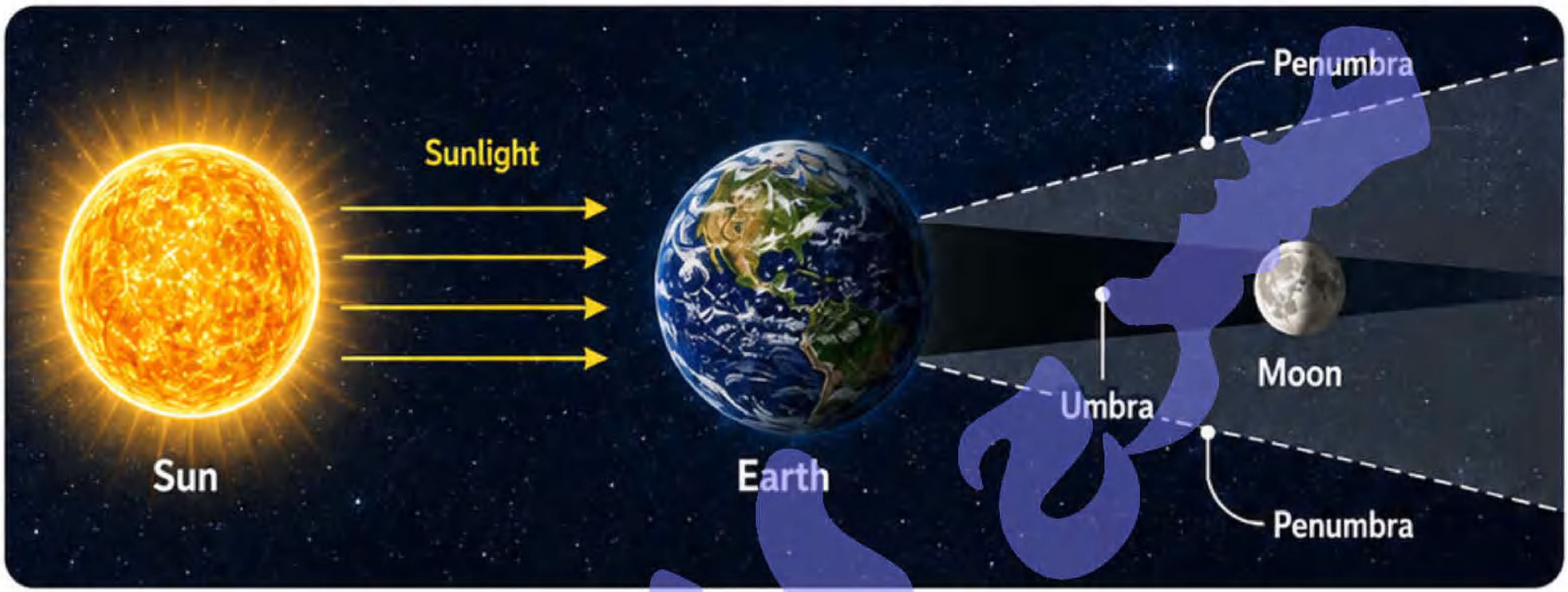
Key Idea

Transparent materials let most light pass and show clear images.
Translucent materials let some light pass and blur images.
Opaque materials block light and create clear shadows.

Lunar Eclipse

When Earth blocks sunlight from reaching the Moon

A **lunar eclipse** is a natural phenomenon that happens when Earth comes between the Sun and the Moon during the full moon phase and blocks sunlight from the Moon, fully or partially.

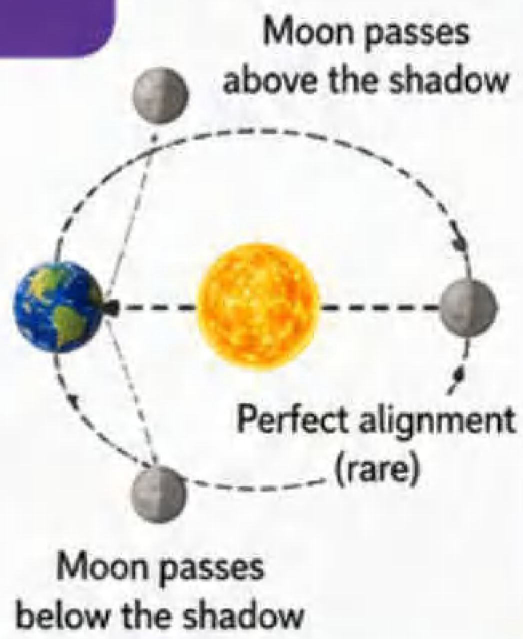

Sunlight
Sun
Earth
Penumbra
Moon
Umbra
Penumbra

Conditions for a Lunar Eclipse

1. It happens at full moon.
2. Earth is between the Sun and the Moon.
3. The Sun, Earth, and Moon must be nearly aligned.

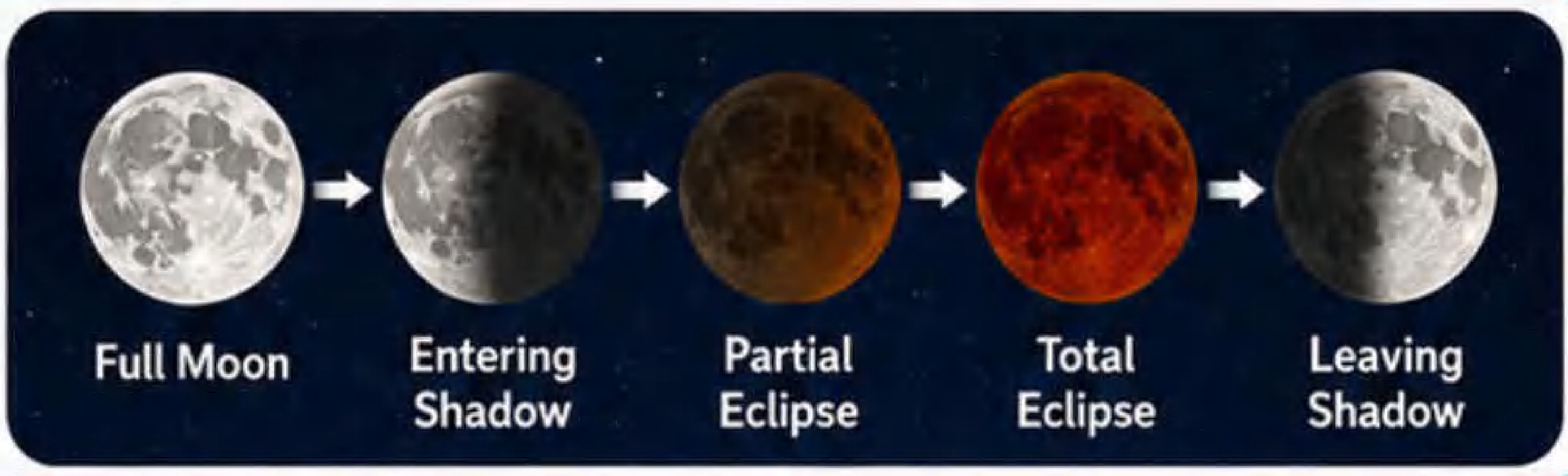
Why It Does Not Happen Every Full Moon

The Moon's orbit around Earth is tilted about 5° relative to Earth's orbit around the Sun. Because of this tilt, the Moon usually passes above or below Earth's shadow, so alignment is not perfect every month.


Moon passes above the shadow
Perfect alignment (rare)
Moon passes below the shadow

What We Observe

During a lunar eclipse, the Moon may darken or appear reddish. This reddish color is caused by sunlight that passes through Earth's atmosphere and bends toward the Moon.


Full Moon
Entering Shadow
Partial Eclipse
Total Eclipse
Leaving Shadow

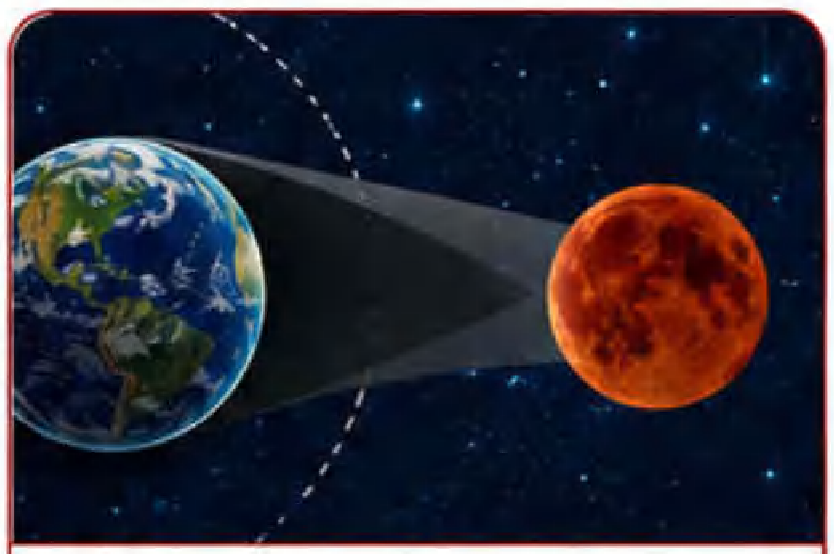
Key Idea

- A lunar eclipse happens at full moon.
- Earth comes between the Sun and the Moon.
- The Sun, Earth, and Moon must be nearly aligned.

Types of Lunar Eclipse and Final Review

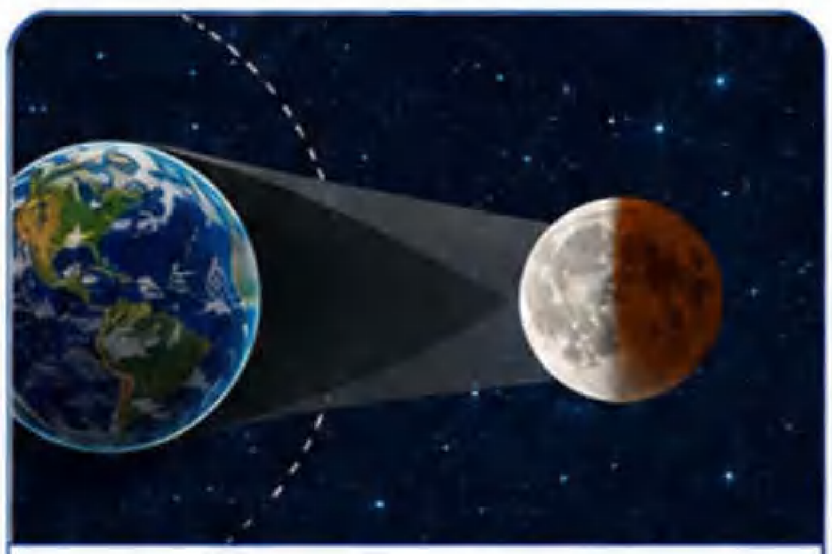
Total, partial, and penumbral lunar eclipse

Lunar eclipses happen when Earth is between the Sun and the Moon.
They can be classified according to how much of the Moon enters Earth's shadow.



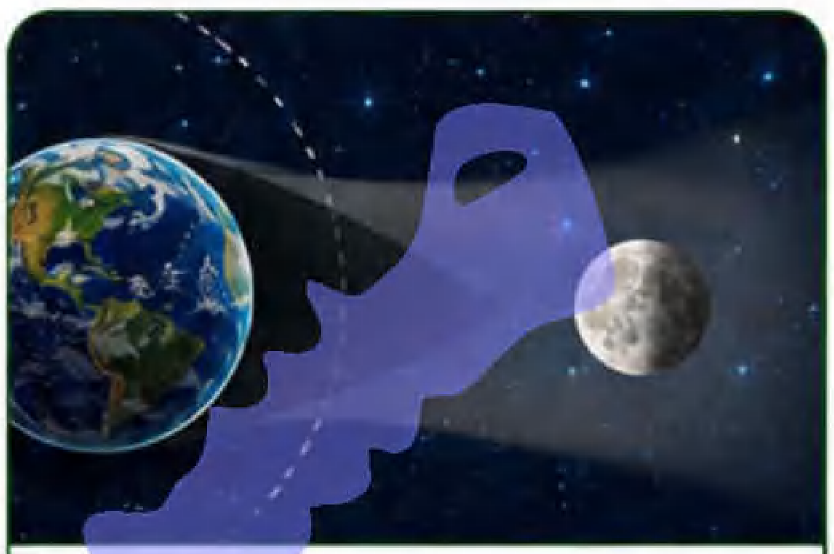
1 Total Lunar Eclipse

The entire Moon enters Earth's umbra. The Moon may appear red or copper-colored due to Earth's atmosphere.



2 Partial Lunar Eclipse

Only part of the Moon enters Earth's umbra. The rest stays in less dark regions.



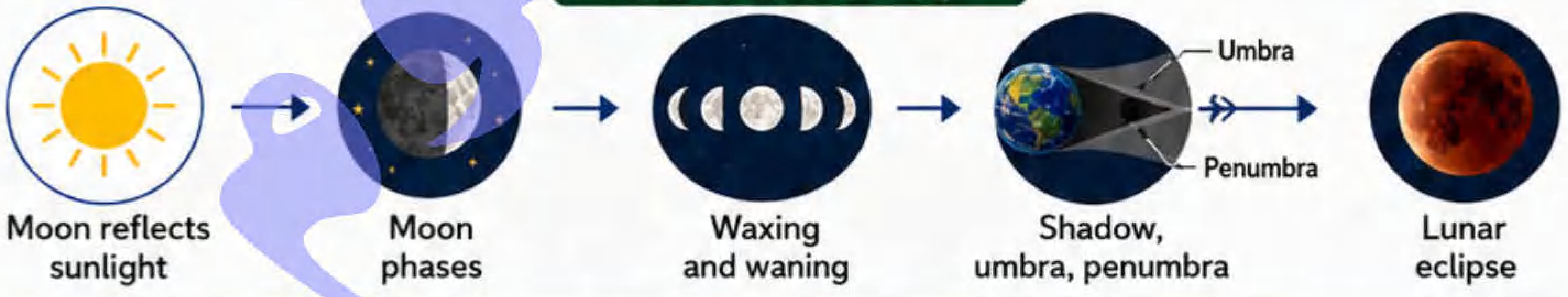
3 Penumbral Lunar Eclipse

The Moon passes through Earth's penumbra, so the darkening is slight and subtle.

Historical Note

In 1504, during his fourth voyage, Christopher Columbus reportedly predicted a lunar eclipse. When it happened as he said, it impressed the local people and helped him gain their trust.

Lesson Review Map



Moon reflects sunlight → Moon phases → Waxing and waning → Shadow, umbra, penumbra → Lunar eclipse

Remember

Moon Phases
Happen every lunar month because the Moon orbits Earth.

Lunar Eclipse
Requires special alignment of the Sun, Earth, and Moon.

Key Idea

- Lunar eclipses occur when Earth is between the Sun and the Moon.
- They can be total, partial, or penumbral depending on how much of the Moon enters Earth's shadow.

موقع الدكتور
محمد رزق
التعليمي

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